FIFTH FIVE-YEAR REVIEW REPORT

FOR

ADVANCED MICRO DEVICES 901/902 AND TRW MICROWAVE SUPERFUND SITES

INCLUDES THE COMPANIES' OFFSITE OPERABLE UNIT

SANTA CLARA COUNTY, CALIFORNIA

PREPARED BY

U.S. Army Corps of Engineers, Seattle District

FOR

U.S. Environmental Protection Agency

Region IX

Approved by: Date:

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9/18/19

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Executive Summary

This is the fifth Five-Year Review (FYR) of the Advanced Micro Devices (AMD) 901/902 Thompson Place Site (AMD Site), the TRW Microwave Superfund Site (TRW Site), and the Companies' Offsite Operable Unit (Offsite OU), located in Sunnyvale, California[1]. The purpose of this FYR is to review information to determine if the remedy is and will continue to be protective of human health and the environment.

The United States Environmental Protection Agency (EPA) issued a Record of Decision (ROD) in 1991 that addressed the AMD Site, the TRW Site and the Offsite OU, as well as the Signetics Site. These three sites and one operable unit have been collectively known by the informal term, "Triple Site".

EPA is the lead agency overseeing environmental investigation and remediation work at the Triple Site. The State of California, San Francisco Bay Regional Water Quality Control Board (Regional Board), was previously the lead agency. On August 7, 2014, EPA Region 9 and the Regional Board agreed to transfer lead agency oversight responsibilities for the Triple Site to EPA Region 9.

This FYR addresses the AMD Site, the TRW Site, and the Offsite OU. The Signetics Site is not addressed in this document because it is not listed on the National Priorities List (NPL), and thus not required by federal Superfund law to be included in the FYR process. However, EPA has been taking steps to establish a broader remedial strategy for regional groundwater restoration through negotiations with Philips Semiconductors, Inc. (Philips), the company responsible for the cleanup for the Signetics Site.

On March 15, 2019, EPA recently entered into an enforcement agreement with Philips which requires the company to perform a Focused Feasibility Study to evaluate options for accelerating the groundwater cleanup at the Signetics Site. The enforcement agreement further requires Philips to assess and mitigate, as necessary, indoor air quality in commercial buildings at the Signetics Site that may be at risk from solvent vapors rising from the contaminated groundwater and accumulating indoors at unacceptable levels (a process called "vapor intrusion").

AMD 901/902 Thompson Place Site

EPA selected the following remedy for the AMD Site in the 1991 ROD: soil excavation; groundwater extraction and treatment; groundwater monitoring; and placement of an environmental covenant prohibiting installation of on-site wells until the completion of groundwater remediation.

Soil excavation at the AMD Site was completed in 1992. A No Further Action letter for the site was then issued by the Regional Board in 2008. The groundwater remedy as described in the 1991 ROD (a groundwater extraction and treatment system [GWETS]) is no longer operating due to declining effectiveness. Portions of the GWETS are now used as part of an in-situ bioremediation (ISB) program to inject and circulate carbohydrate amendment. AMD submitted a draft Focused Feasibility Study to EPA in October 2013 and EPA will amend the remedies once vapor intrusion investigations and Focused Feasibility Studies are complete for AMD, TRW, Signetics and the Offsite OU.

Four contaminants, TCE, cDCE, tDCE, and vinyl chloide, remain at concentrations above groundwater cleanup standards at the AMD Site. Contamination is confined to the shallow groundwater-bearing zones

[1] During cleanup, a site can be divided into a number of distinct areas depending on the complexity of the problems associated with the site. These areas called operable units may address geographic areas of a site, specific site problems, or areas where a specific action is required.

(A, B1, and B2 zones). Remedial efforts have greatly reduced TCE concentrations in the original source areas. Levels of TCE degradation products, cDCE and vinyl chloride, have increased in the ISB treatment areas, indicating that degradation is occurring but that it is incomplete. Contamination from off-site, upgradient sources, including the Signetics Site, continues to occur.

There have been no changes to the Applicable, Relevant and Appropriate Requirements (ARARs) which groundwater cleanup goals were based on. Land use has not changed since the last FYR. Exposure pathways from soil and groundwater are being controlled. An environmental covenant was recorded in 2005 for the AMD Site that prohibits residential land use, groundwater well installation, and soil excavation but the Regional Board was not a signatory to the covenant.

EPA evaluated vapor intrusion in 2014; results indicate that potential indoor air exposures due to groundwater contamination at the AMD Site are not a concern under the current commercial land use.

The remedy at the AMD Site currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled and there is no evidence of unacceptable vapor intrusion for the current commercial land use. However, in order for the remedy to be protective in the long-term, a revised final groundwater remedy for the AMD Site should be selected, as the remedy selected in the 1991 ROD is no longer operating. The revised remedy should also address potential vapor intrusion in the event of future land use changes, as vapor intrusion was not addressed in the 1991 ROD and record a new environmental covenant that includes the Water Board as a signatory.

TRW Microwave Site

In the 1991 ROD, EPA selected the following remedy for the TRW Site: groundwater extraction; treatment of extracted groundwater by air stripping; groundwater monitoring; discharge of treated water under a National Pollutant Discharge Elimination System (NPDES) permit; and institutional controls, including restrictive and environmental covenant, which include prohibiting residential land use and extraction of groundwater.

A GWETS operated at the TRW Site between 1986 and 2001. Between 1993 and 1998, a soil vapor extraction and treatment system was also used to facilitate cleanup of residual contamination. Due to declining effectiveness, the GWETS was discontinued in 2001. Northup Grumman, the company conducting the TRW cleanup, subsequently proposed to study enhanced anaerobic biodegradation (EAB) as a possible remedy for groundwater. Pilot testing for EAB began in 2000 and was expanded in 2005. EAB has achieved some success in reducing chemical contaminants concentrations, although rebound has been observed. A draft Focused Feasibility Study was completed in 2011 and is currently being revised. Recent site investigation data were incorporated into an updated Conceptual Site Model that identified various preferred contaminant migration pathways in the aquifers.

Overall, remedial efforts have substantially reduced chemical contaminant concentrations in the source area and in the aquifer A, B1, and B2 zones since implementation of the remedy. Achievement of cleanup goals will remain a challenge as long as the migration of chemical contaminants from upgradient sources, including the Signetics Site, continues to occur.

TRW conducted an initial vapor intrusion evaluation at the TRW Site which indicated that TCE concentrations in indoor air near the former source area present an inhalation risk, exceeding the applicable commercial screening levels. Mitigation efforts (installation of a sub-slab passive venting system, with the capability of being converted to an active system as necessary) were completed in 2015. Confirmatory indoor air sampling following the completion of the mitigation activities showed levels of

chemical contaminants below levels considered safe, confirming the success of the mitigation measures in addressing the inhalation risk.

There have been no changes to the ARARs which groundwater cleanup goals were based on since the ROD was issued. Land use has not changed since the last FYR. Exposure pathways for soil and groundwater are being controlled. A covenant and agreement that prohibits use of groundwater, excavation of soils and prohibits land use for was recorded in 1992.

The remedy at the TRW Site currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled. Exposure pathways to contaminated groundwater that could result in unacceptable risks are addressed in an environmental covenant. The risk due to vapor intrusion for the current commercial land use has been addressed. However, in order for the remedy to be protective in the long-term, a revised soil and groundwater remedy for the TRW Site should be selected, as the remedy selected in the ROD is no longer operating. The revised remedy should also address vapor intrusion assessment and response procedures to ensure the long-term stewardship of the vapor intrusion mitigation measures currently in place, as well as potential vapor intrusion in the event of future land use changes, as vapor intrusion was not addressed in the 1991 ROD.

Offsite Operable Unit

The Offsite OU extends north from the Signetics Site and encompasses an area of about 100 acres. The area includes four schools and more than 100 residences. Groundwater contamination in the Offsite OU is due to commingled, upgradient sources, including the Signetics, AMD and TRW Sites.

In the 1991 ROD, EPA selected expanded groundwater extraction; treatment of extracted groundwater by air stripping; and reuse or discharge of the treated groundwater to surface water under an NPDES permit. EPA estimated that the groundwater in the Offsite OU would be restored in 36 years.

Generally, the remedy appears to be containing contaminants migrating from upgradient sources and preventing further downgradient migration. The concentration footprint of the plume has not significantly changed within the review period indicating containment is occurring. Groundwater restoration within the Offsite OU did not progress substantially and is not expected to be achieved in a reasonable timeframe. The current understanding of the subsurface is simplified and does not account for the potential for highly channelized flow. A remedy optimization, and possible a new remedy, is needed in order to restore the aquifer in a reasonable timeframe.

There have been no changes to the ARARs which groundwater cleanup goals were based on since the 1991 ROD. Land use is primarily residential. Institutional controls are in place to prevent well installation in Santa Clara County, and a municipal water supply exists for the area (Hetch Hetchy Reservoir in the Sierra Nevada Mountains).

A vapor intrusion assessment in the Offsite OU began in 2015 and is ongoing. To date, more than 225 households and 40 school buildings have been sampled and more than 20 mitigation systems have been installed in residential and school buildings to address findings of unacceptable vapor intrusion [i.e., indoor air TCE levels due to vapor intrusion exceeding the short-term screening level of 2.0 micrograms per cubic meter ($\mu g/m^3$)]. Mitigation efforts have largely consisted of installation of sub-slab or sub-membrane depressurization systems, ventilation upgrades, conduit sealing, installation and operation of indoor air purifiers, Operations & Maintenance (O&M) measures, and post-mitigation confirmatory indoor air sampling to confirm success of mitigation measures at achieving protective levels of TCE.

Sampling of ambient outdoor air has occurred regularly in the Offsite OU since January 2015, in conjunction with indoor air sampling events in residences and schools. While outdoor air TCE levels have often been low, periodic spikes have been observed of up to 3.6 $\mu g/m^3$, with a general upward trend in these spikes over time. To be protective in the long-term, an investigation into the contributions to outdoor air TCE levels from fugitive emissions from the groundwater treatment system and emissions from the vapor intrusion mitigation system vent stacks should be conducted.

The remedy for the Offsite OU currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled. The risk due to vapor intrusion for the current residential use is being addressed through installation of mitigation measures. However, in order for the remedy to be protective in the long-term, a remedy performance optimization and updated site conceptual model is needed. A revised remedy may be needed to achieve the RAOs and to address vapor intrusion assessment and response procedures to ensure the long-term stewardship of the vapor intrusion mitigation measures currently in place. Finally, an investigation of the contributions to outdoor air TCE levels from fugitive emissions from the groundwater treatment system and emissions from the vapor intrusion mitigation systems is needed.

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List of Abbreviations

1,1-DCA	1,1-dichloroethane
1,2-DCB	1,2-dichlorobenzene
1,1-DCE	1,1-dichloroethylene
1,1,1-TCA	1,1,1-trichloroethane
AOC	Administrative Order on Consent
AMD	Advanced Micro Devices
ARAR	applicable or relevant and appropriate requirements
cDCE	cis-1,2-dichloroethylene
DNAPL	Dense non-aqueous phase liquid
EAB	enhanced anaerobic biodegradation
EPA	Environmental Protection Agency
FFS	Focused Feasibility Study
FYR	Five-Year Review
GWETS	groundwater extraction and treatment system
HRC	hydrogen release compound
HVAC	heating and ventilation systems
ISB	in-situ bioremediation
MCL	maximum contaminant limit
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OU	operable unit
PCE	tetrachloroethylene
PRP	potentially responsible party
RAO	remedial action objectives
ROD	Record of Decision
RP	Responsible Party
RSL	regional screening level
SCVWD	Santa Clara Valley Water District
TCE	trichloroethylene
tDCE	trans-1,2-dichloroethylene
USACE	United States Army Corps of Engineers
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compounds

1. Introduction

The purpose of a Five-Year Review (FYR) is to evaluate the implementation and performance of a remedy to determine if the remedy will continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in FYR reports. In addition, FYR reports identify issues found during the review, if any, and document recommendations to address them.

The U.S. Environmental Protection Agency (EPA) is preparing this FYR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121, 40 Code of Federal Regulation Section 300.430(f)(4)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and EPA policy.

This is the fifth FYR for the Advanced Micro Devices (AMD) 901/902 Thompson Place Site (AMD Site), TRW Microwave Superfund sites (TRW Site), and the Companies' Offsite Operable Unit (Offsite OU). The triggering action for this statutory review is the completion of the previous FYR on September 30, 2013. The FYR has been prepared due to the fact that hazardous substances, pollutants, or contaminants remain at the AMD Site, TRW Site, and Offsite OU above levels that allow for unlimited use and unrestricted exposure.

The FYR was led by Melanie Morash, EPA, Remedial Project Manager. Participants included Rebecca Rule, U.S. Army Corps of Engineers (USACE), Project Manager; Jacob Williams, USACE, Chemist; and Kris Addis, USACE, Geologist. The review began on October 1, 2018.

Table 1. Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Advanced Micro Devices 901/902 and TRW Microwave Superfund Sites		
EPA ID: CAD048634059 (AMD) and CAD009159088 (TRW)		
Region: 9	**State:** CA	**City/County:** Sunnyvale, Santa Clara County
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes	
REVIEW STATUS		
Lead agency: EPA		
Author name (Federal or State Project Manager): Melanie Morash		
Author affiliation: USEPA Region 9		
Review period: 10/1/2018 – 7/1/2019		
Date of site inspection: 3/14/2019		
Type of review: Statutory		
Review number: 5		
Triggering action date: 9/30/2014		
Due date *(five years after triggering action date)*: 9/30/2019		

1.1. Background

The AMD site, TRW site, and Offsite OU are clustered together on relatively flat land south of San Francisco Bay in Sunnyvale, California. The sites and operable unit (OU) reviewed for this FYR are the AMD Site, TRW Site, and Offsite OU. Together with an adjacent site – the Signetics Site– these three Sites and one OU are collectively known by the informal term, "Triple Site."

The Signetics Site is not addressed in this document because it is not listed on the National Priorities List (NPL), and thus not required by federal Superfund law to be included in the FYR process. The Signetics Site was proposed for listing on the NPL but was ultimately not listed because it was being regulated under a different federal program, the state-authorized Resource Conservation and Recovery Act program. The AMD 915 DeGuigne Drive Superfund Site is addressed under a separate ROD and is not addressed in this FYR (being addressed under a separate FYR).

AMD 901/902 Thompson Place Site

The AMD site boundary, as defined in the ROD, includes the location of two former large, low-rise industrial buildings connected by a hallway (formerly 901 and 902 Thompson Place) and extends east to DeGuigne Drive. As defined, the AMD site includes seven other commercial buildings; however, these seven buildings do not overlie groundwater impacted by former AMD operations.

AMD manufactured printed circuit boards and semiconductors continuously at the AMD Site between 1969 and 1992. During this time, AMD used trichloroethylene (TCE) and other industrial solvents for cleaning and degreasing, although TCE use reportedly ceased around 1979. Acids were used for etching, and caustics were used for acid neutralization. Acid neutralization systems, including in-ground sumps, were used at both AMD buildings between 1969 and 1984. Related hazardous wastes generated from these various operations were stored on-site.

In 1982, leakage from an acid neutralization sump at the former 901 Thompson Place building initiated site investigations. The sump in the former 902 Thompson Place building was subsequently found to also be leaking. Additional studies of groundwater contamination in the 1980s identified chlorinated volatile organic compounds (VOCs), primarily TCE and its biodegradation products, cis-1,2-dichloroethylene (cDCE) and vinyl chloride, in the upper 65 feet of soil under the AMD Site. The maximum historical TCE concentration found in groundwater was 110,000 micrograms per liter (µg/L) at well 28-S, located near the neutralization tank adjacent to the former 902 Thompson Place building.

TRW Microwave Site

The former TRW Microwave site is located to the north of the AMD Site, also in a topographically flat area of the Santa Clara Valley. The on-site building has been vacant since January 2001. Between 2001 and 2003, a portion of the building was demolished and a new structure, contiguous with the remaining portion of the existing building, was constructed.

TRW assembled and tested microwave and semiconductor components at the TRW Site between 1968 and 1993. TRW used TCE and several other industrial solvents and hazardous compounds; hazardous wastes were generated as a by-product of the operations. TRW stored waste solvents (mostly TCE) in an

underground storage tank from 1970 through 1982. The tank was removed in early 1983. An in-ground, three-stage, ammonia gas acid neutralization system also operated from 1968 to 1984, when it was disconnected and removed. It was replaced by an aboveground system with secondary containment. The aboveground acid neutralization system was disconnected and removed in 2001, during remodeling of the site building.

TRW initiated an investigation of potential impacts to soil and groundwater at the TRW Site following the removal of the underground storage tank. Between 1983 and 1986, several subsurface investigations were conducted in the vicinity of the former areas of the underground storage tank, the acid neutralization systems, and associated piping. The investigations identified VOCs as the only contaminants of concern at the TRW Site, and the former underground storage tank area as the only source of VOCs impacting groundwater at the TRW Site.

Offsite Operable Unit

The Offsite OU extends north from the AMD and TRW Sites and represents the largest OU in spatial extent. The Offsite OU was originally mapped to encompass a single commingled groundwater contaminant plume composed primarily of dissolved trichloroethylene (TCE).

In the 1980s, investigations began in the groundwater north of Duane Avenue to provide information on the vertical and horizontal extent of contamination in the Offsite OU. Contaminants were discovered in groundwater but were not observed in the soil in the Offsite OU. Due to the lack of potential sources in the Offsite OU, the sources for the observed contaminant concentrations were attributed to AMD, TRW and Signetics sites located up-gradient of the area. A commingled plume of contaminated groundwater, approximately 4,000 feet long, underlies the land in the Offsite OU and extends beyond Highway 101 to the north. Chemical contaminants in the groundwater plume are primarily chlorinated VOCs, predominantly TCE.

The Offsite OU encompasses an area of about 100 acres. The area includes four schools and more than 100 residential buildings. The schools include a daycare/preschool, two elementary schools, and one middle/high school. Concentrations of chemical contaminants in groundwater beneath many of the residences and some schools have yet to be determined.

Related Site– Signetics Site

On August 7, 2014, EPA Region 9 and the State of California, San Francisco Bay Regional Water Quality Control Board (Regional Board), agreed to transfer lead agency oversight responsibilities for the Triple Site, including the Signetics Site, from the Regional Board to EPA Region 9. EPA recently entered into an enforcement agreement with Philips Semiconductors, Inc. (Philips) for the Signetics Site, which requires the company to conduct a focused feasibility study to evaluate options for accelerating the groundwater cleanup at the Signetics Site. The enforcement agreement further requires Philips to assess and mitigate, as necessary, indoor air quality in commercial buildings at the Signetics Site that may be at risk from solvent vapors rising from the contaminated groundwater and accumulating indoors at unacceptable levels (a process called "vapor intrusion").

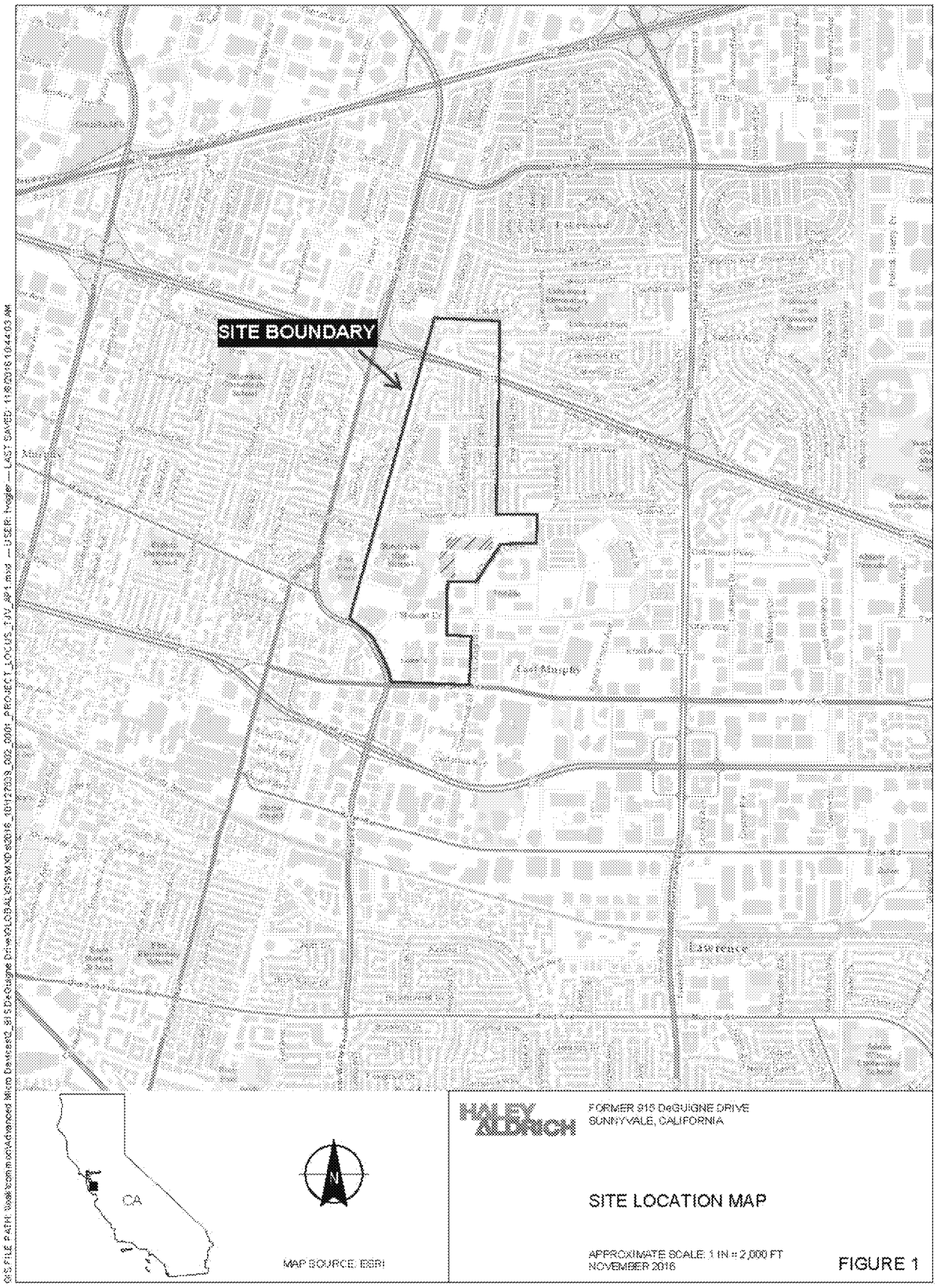


Figure 1. Location Map for the AMD 901/902 and TRW Superfund Sites and Offsite OU

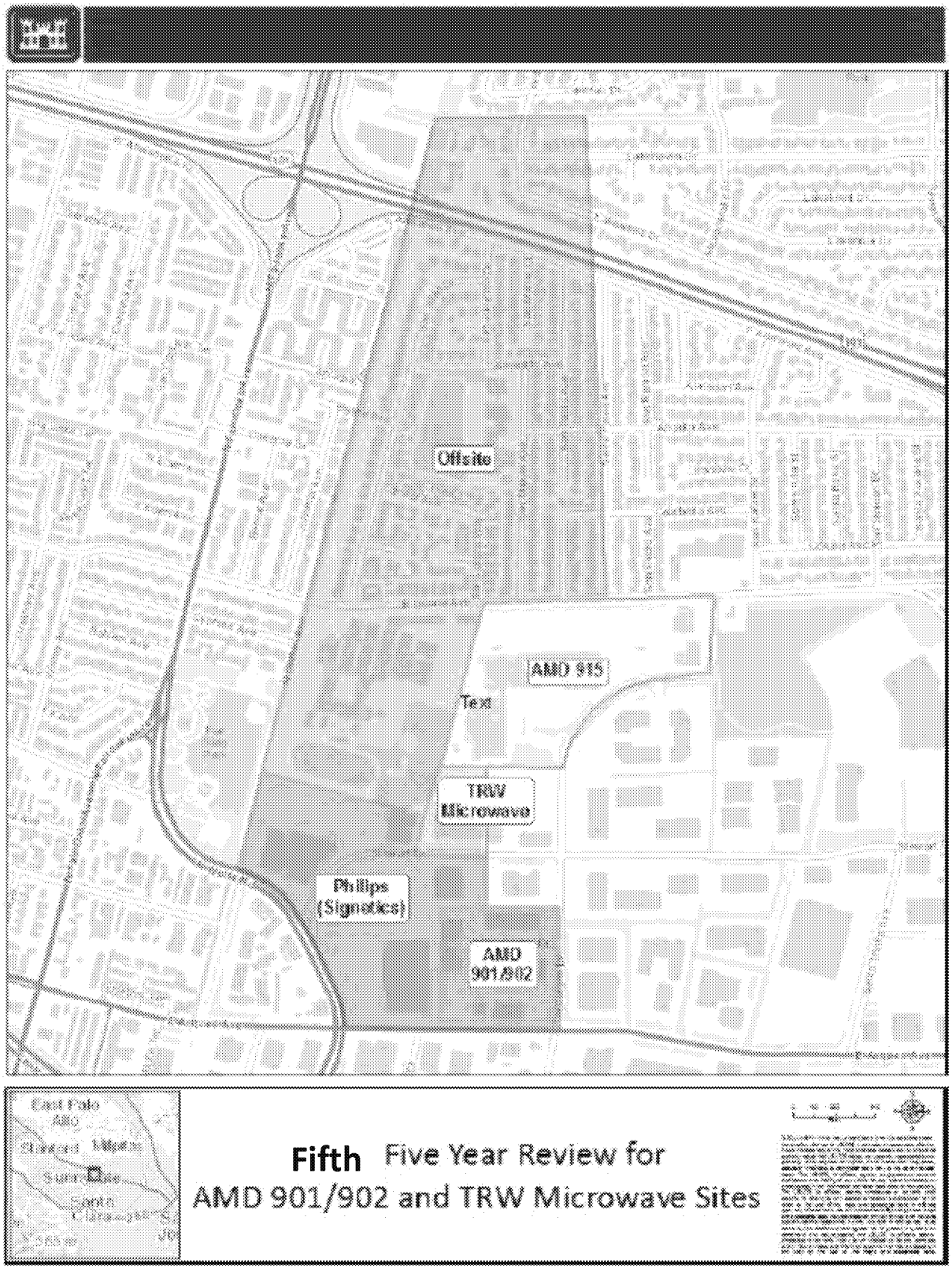


Figure 2. Detailed Map of the AMD 901/902 and TRW Superfund Sites, the AMD 915 Site and Offsite OU

1.2. Physical Characteristics

AMD 901/902 Thompson Place Site

Prior to the late 1960s, land use in Santa Clara County was agricultural, predominantly commercial fruit orchards. Industrial operations began at the AMD Site in 1969 when AMD began manufacturing printed circuit boards and semiconductors at 901 Thompson Place. AMD began operations at the former 902 Thompson Place building in 1972, operating the combined facility until 1992. Operations were continuous with no significant process changes until 1992.

AMD discontinued operations and vacated the two buildings in 1992. The AMD Site was sold to Westcore Thompson II, LLC in 2005; the AMD Site was later transferred to Summit Commercial Properties, Inc. Summit demolished the two buildings in 2006 and built the existing self-storage warehouse in 2007. The address was also changed from 901/902 Thompson Place to 875 East Arques Avenue at that time.

The AMD Site boundary, as defined in the ROD, includes the location of the two former low-rise industrial buildings connected by a hallway (formerly 901 and 902 Thompson Place) and extends east to DeGuigne Drive (Figure 2). As defined, the AMD Site includes seven other commercial buildings; however, these seven buildings do not overlie groundwater impacted by former AMD operations. Groundwater impacted by VOCs beneath these buildings appears to be attributable to off-site, up-gradient sources. A self-storage warehouse built in 2007 currently occupies the former footprint of the 901 and 902 Thompson Place buildings. The area immediately surrounding the property is a mix of light commercial use and residential properties.

TRW Microwave Site

Industrial operations began at the TRW Site in 1968, when Aertech Industries began assembling and testing microwave and semiconductor components. In 1974, TRW acquired the site from Aertech and continued similar operations. In 1987, FEI Microwave purchased the site from TRW; FEI Microwave subsequently became Tech Facility 1, Inc. FEI Microwave operated the facility until 1993. Operations were continuous with no significant process changes between 1968 and 1993. In 1995 the TRW Site was acquired by Stewart Associates and subsequently leased to Diablo Research Corporation and Cadence Inc. for research and development operations.

In 2002, TRW merged with Northrop Grumman Systems Corporation (Northrop Grumman). In 2004, the property was purchased by Pacific Landmark. The property ownership changed again in May 2014 to Hines. During these changes in ownership of the TRW Site, TRW, and then Northrop Grumman, retained responsibility for the site cleanup. The building is currently occupied and is zoned for light industrial use. The area immediately surrounding the property is light commercial with a mix of residential properties.

Offsite Operable Unit

The Offsite Operable Unit (Offsite OU or OOU) is primarily a residential neighborhood consisting of single-family and multi-family homes and includes 4 schools. The Offsite OU does not contain any buildings or properties from which the former Companies (AMD, TRW, and Philips/Signetics) caused soil and groundwater contamination through their industrial operations. Directly to the north and down-

gradient of the AMD, TRW, and Philips OUs is the former high school for the City of Sunnyvale, which was used until the early 1980s. Subsequently, the school was leased for a number of years to house an engineering center. Currently, the buildings at the 790 East Duane Avenue property are occupied by the daycare/elementary school. Adjacent to this property are a preschool and daycare and a high school, and within the approximate center of the Offsite OU is an elementary school.

1.3. Hydrology

The AMD and TRW sites and the Offsite OU are located in the Santa Clara Valley, a structural basin bounded by the Santa Cruz Mountain to the south and west, and the Diablo Range to the north. The sites are underlain by alluvial sequences eroded from the Santa Cruz Mountains and deposited in the basin in north-trending streams en route to San Francisco Bay. The depositional environment is characterized by meandering and braided stream systems that created sequences of coarse-grained units interbedded with fine-grained clay and silt.

The alluvial sediments at the sites are divided into two hydrogeologic zones referred to as the Upper Aquifer and the Lower Aquifer. These two zones are separated by a relatively impermeable aquitard at approximately 120 feet below ground surface. The Lower Aquifer, an extensive, deep, regional, confined aquifer, lies underneath the aquitard. Municipalities utilize some wells within this deep regional aquifer for drinking water. However, the Santa Clara Valley Water District supplies drinking water for this part of Sunnyvale from the Hetch Hetchy Reservoir in the Sierra Nevada Mountains, and tests the supply to ensure that all state and Federal drinking water standards are met.

Regional Designation	Local Zone Designation	Approximate depth below ground surface (ft)	HSU Identified
Upper Aquifer	A		
		20	
	B1		TRW HSU 1-3
		40	
	B2		
		60	
	B3		
		80	
	B4		
		100	
	B5		
Regional Aquitard	B-C Aquitard	120	
Lower Aquifer	C Aquifer	300	
		500	

Note: Hydrostratigraphic units (HSU) consist of very permeable coarse-grained material inferred to be relic channel deposits that generally trend north/south. These channel deposits are surrounded by low-permeability silts and clay inferred to be overbank stream deposits. The channel deposits provide preferred pathways for contaminant migration hydraulically downgradient from the source area.

Figure 3. Aquifer designations with associated water bearing zones and Hydrostratigraphic Units.

The Upper Aquifer is divided into six water-bearing zones, Zone A, and Zones B1 through B5 (Figure 3). The Upper Aquifer consists of transmissive sand and gravel units vertically and laterally separated by low permeability units of silt and/or clay. Groundwater flow direction for all upper zones is generally to the north, toward San Francisco Bay. Groundwater extraction wells within the Upper Aquifer in the Offsite OU and at the adjacent Signetics and AMD 915 sites impact local groundwater direction and gradient.

The water-bearing zones appear to be laterally continuous throughout the AMD and TRW sites and Offsite OU, and range from silty sand to sand and gravel. Recent studies identified several higher

permeable units within a single water-bearing zone. Each zone has a heterogeneous composition, and contains lenses that are highly discontinuous and more permeable than surrounding soil.

Northup Grumman, the company responsible for the TRW Site, updated their Conceptual Site Model and detailed the depositional environment of alluvial deposits in the Triple Site area[2]. Numerous hydrostratigraphic units (HSU) were identified within A, B1, and B2 Zones. These hydrostratigraphic units have not been projected or identified to any significant extent beyond the TRW Site. Permeable channel deposits representing hydrostratigraphic unit preferred pathways have been identified in the A and B1 Zones at the Signetics Site.

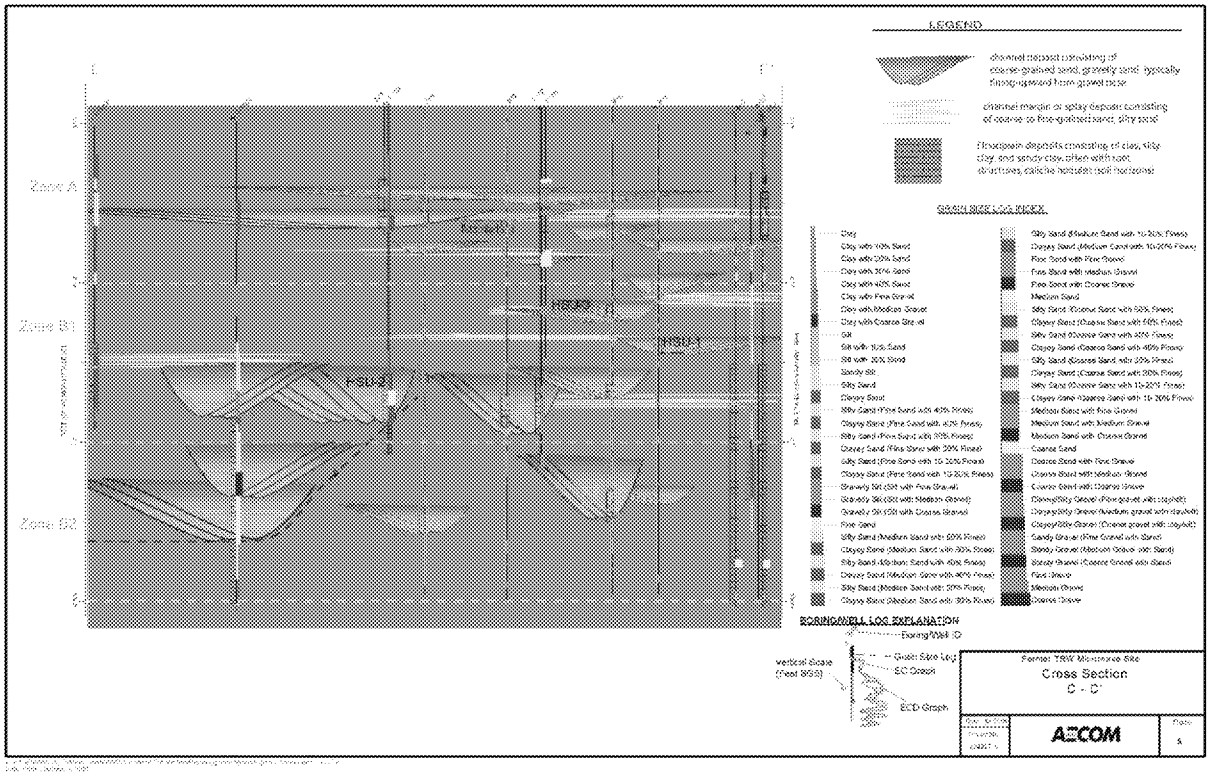


Figure 4. Cross-Section Showing hydrostratigraphic units in the A, B1, and B2, Zones Beneath the TRW Site

[2] A Conceptual Site Model is comprehensive graphical and written summary of what is known or hypothesized about environmental contamination at a site. It provides a platform for evaluating the data gaps and related uncertainty associated with site history and operations; geology, hydrogeology and hydrology; contaminant sources, release mechanisms and fate and transport; potential receptors and exposure pathways.

2. Remedial Actions Summary

2.1. Basis for Taking Action

The presence of chlorinated VOCs in soil at the AMD and TRW sites and in groundwater at the AMD and TRW sites and Offsite OU provided the basis for taking action. The release of hazardous substances into the environment at the sites posed, or potentially posed, a threat to human health and the environment via inhalation, ingestion, and direct contact.

2.2. Remedy Selection

The combined ROD for the AMD, TRW, Signetics, and Offsite OU was signed on September 11, 1991.

The remedial action objectives (RAOs) selected are:

- Prevention of the near-term and future exposure of human receptors to contaminated groundwater and soil;
- Restoration of the contaminated groundwater for future use as a potential source of drinking water;
- Control of contaminant migration; and
- Monitoring of contaminant concentrations in groundwater to observe the control of contaminant migration and the progress of cleanup.

The ROD estimated that the restoration of groundwater at the TRW Site would occur in seven years; at the AMD 901/902 Site would occur in 18 years; and at the Offsite OU would be achieved in 36 years. Volatilization of groundwater contaminants from the subsurface was not considered for AMD 901/902, TRW or Signetics because there were no residential properties at the time of the ROD. The ROD identified the potential for vapor intrusion for the Offsite OU, but deferred evaluation of the risk for further Five-Year Reviews because at the time of the ROD, the understanding of vapor intrusion was unclear.

The ROD selected state Maximum Contaminant Levels (MCLs) for groundwater cleanup standards for nine of the ten chemical contaminants (Table 2). Due to the lack of a state MCL for 1,2-dichlorobenzene (1,2-DCB), the cleanup level was set at the Federal MCL. No soil cleanup levels were selected in the ROD for the AMD Site, the TRW Site, or the Offsite OU.

Table 2. Groundwater Cleanup Standards

Chemical	Cleanup Standard (µg/L)	Source	Applicable Sites and Offsite OU
1,1-DCA	5	CA MCL	AMD 901/902, TRW, Offsite
1,2-DCB	600	Federal MCL	AMD 901/902, TRW
cDCE	6	CA MCL	AMD 901/902, TRW, Offsite
Trans-1,2-DCE	10	CA MCL	AMD 901/902, TRW, Offsite
1,1-DCE	6	CA MCL	AMD 901/902, TRW, Offsite
Freon 113	1200	CA MCL	AMD 901/902, TRW, Offsite

Chemical	Cleanup Standard (µg/L)	Source	Applicable Sites and Offsite OU
PCE	5	CA MCL	AMD 901/902, TRW, Offsite
TCE	5	CA MCL	AMD 901/902, TRW, Offsite
1,1,1-TCA	200	CA MCL	AMD 901/902, TRW, Offsite
Vinyl Chloride	0.5	CA MCL	AMD 901/902, TRW

AMD 901/902 Thompson Place Site

The remedy selected in the ROD for the AMD 901/902 Site consists of the following elements:

- Soil excavation followed by off-site incineration/disposal of the remaining contaminated soil beneath the AMD 901/902 Site;
- Continued groundwater extraction and treatment by air stripping;
- Groundwater monitoring; and
- Placement of a restrictive covenant prohibiting installation of on-site wells until groundwater remediation is completed.

TRW Microwave Site

The remedy selected in the ROD for the TRW Site consists of the following elements:

- Groundwater extraction;
- Treatment of extracted groundwater by air stripping;
- Discharge of treated water under a National Pollutant Discharge Elimination System (NPDES) permit; and
- Institutional Controls, including restrictive and environmental covenants, which include prohibition of residential land use, prohibition of groundwater extraction, and continued groundwater monitoring.

Offsite OU

The remedy selected in the ROD for the Offsite OU consists of the following elements:

- Expanded groundwater extraction;
- Treatment of extracted groundwater by air stripping (at the time at the nearby AMD 915 Site, since relocated to the Signetics Site at 813 Stewart Drive); and
- Reuse or discharge of the treated groundwater to surface water under a NPDES permit.

2.3. Remedy Implementation

AMD 901/902 Thompson Place Site

In response to the 1991 Site Cleanup Requirements and ROD, an additional 94 cubic yards of soil were excavated from the AMD Site in 1992. The contaminated soil was disposed of off-site, and the remaining uncontaminated soil was used as backfill. The Regional Board reviewed the relevant soil and groundwater sampling results for VOCs and issued a No Further Action letter, dated May 14, 2008, to confirm completion of site investigation and remedial actions for releases with respect to unsaturated zone (shallow) soil at the AMD Site. Foundation demolition work occurred at the AMD Site on July 27, 2016, and residual impacted soil was encountered during deep earthwork. Approximately 580 cubic yards of soil were excavated and disposed of off-site.

Groundwater remediation is still ongoing at the AMD Site. The groundwater extraction and treatment system (GWETS) began operation in 1983 with three extraction wells, was expanded to a total of eight extraction wells in 1993 (wells DW-1 through DW-8), and continued operation through 2002. The GWETS pumped water from the A, B1, and B2 zones to an on-site treatment system where VOCs were removed from the extracted water by air-stripping. Treated water was discharged under a NPDES permit to the storm sewer or put to reuse on-site.

Although concentrations of chemical contaminants associated with on-site releases decreased as a result of the GWETS operation, the rate of chemical contaminant concentration reduction was marginal. Because of the declining effectiveness of the selected remedy, in-situ bioremediation (ISB) was tested to accelerate the groundwater cleanup. Pilot testing for ISB began in 2002, and full-scale ISB commenced in 2005. During the pilot study, in which carbohydrate was injected into the groundwater to stimulate microbial processes, TCE, cDCE, and vinyl chloride concentrations were reduced in pilot test wells by over 90 percent within six months.

Following the successful demonstration of the ISB pilot test, AMD expanded the ISB program and integrated the GWETS to assist circulation. Use of the GWETS as a groundwater circulation tool was shown to be effective in distributing carbohydrate throughout the treatment zone. ISB activities are currently ongoing.

An environmental covenant prohibiting residential land use, groundwater well installation, and soil excavation was recorded for the AMD Site in 2005.

In September 2013, a revised Focused Feasibility Study (FFS) was completed that evaluated groundwater extraction and treatment, ISB, monitored natural attenuation, and a permeable reactive barrier as potential revised remedies for the site.

TRW Microwave Site

Interim actions at the TRW Site began in 1983 with the removal of the waste solvent Underground Storage Tank and associated contaminated soil. Additional soil, ultimately totaling 120 cubic yards, was removed from this area in 1984. Due to the proximity of the excavation to the foundation of the 825 Stewart Building, not all of the contaminated soil could be removed.

The GWETS and groundwater monitoring program at the TRW Site were fully implemented at the time the final Site cleanup Requirements and ROD were adopted in 1991.

Following the signing of the ROD in 1991, TRW began soil vapor extraction and treatment in July 1993 to enhance cleanup in the unsaturated zone in the vicinity of the former underground storage tank area. The soil vapor extraction and treatment system operated full-time through November 1996 and removed approximately 140 pounds of TCE. The system was removed in November 1998 and the Regional Board issued a letter stating that no further action was required in the vadose zone.

Decreases in TCE groundwater concentrations were most dramatic during the first five years of GWETS operation (1985 to 1990). During the 1990s, TCE concentrations appeared to have reached near asymptotic levels. In 1998, TRW concluded that the GWETS had reached its limit of effectiveness, due to the limited ability of the GWETS to flush out chemical contaminants in the silty/clayey zones of the aquifer system. In 2000, the TCE mass removed was only 30 percent of that removed in 1985, and in 2001, the Regional Board approved permanent suspension of groundwater extraction.

The GWETS was shut down in the source area in October 2000 to allow an enhanced anaerobic biodegradation (EAB) treatability study, to address high concentrations of chemical contaminants in groundwater near the on-site source area outside of the excavation. Complete GWETS shutdown occurred in April 2001 with the approval of the Regional Board. At the request of the current property owner, the above-ground GWETS components were dismantled and removed in November 2012. The eight wells originally designed for use in the GWETS remain in use for groundwater monitoring and are part of a 47-well on-site monitoring well network.

The EAB treatment utilized an injection of Hydrogen Release Compound into source area B1 zone wells. A follow-up injection into A zone and additional B1 zone wells occurred in June 2001. Following a successful pilot program, the EAB program was expanded in 2005 to include the area immediately down-gradient of the former source area. Between 2007 and 2008, emulsified vegetable oil and neat vegetable oil were injected into source area wells to generate reducing conditions and to sequester chlorinated VOCs within the neat oil introduced into the pea gravel-filled excavation. Following the injections, two additional carbon substrates, were injected down-gradient of the former site source area in November 2011.

In October and November 2014, an opportunity arose to excavate additional contaminated soils from the source area during property redevelopment. A targeted excavation was conducted, during which approximately 590 tons of soil and semi-solids were removed from the source area.

Extraction wells are generally installed near the down-gradient site boundary to reduce the potential to impact down-gradient properties. Injection wells are generally installed up-gradient of the former chemical contaminant source area. Annual groundwater monitoring and EAB activities continue at the TRW Site.

A draft Focused Feasibility Study was completed in 2011 that evaluated several remedies, including groundwater extraction and treatment, EAB, institutional controls, monitored natural attenuation, and in-situ chemical oxidation. This Focused Feasibility Study is currently being updated by Northup Grumman

to reflect additional data and findings from investigative and remedial work that has occurred at the TRW Site subsequent to 2011.

Offsite OU

Twenty-nine extraction wells are operating within the Offsite OU. The wells are clustered into four parallel groups, based on location. From south to north, the well groupings are Duane Avenue, Carmel Avenue, Alvarado Avenue, and Ahwanee Drive. The Duane Avenue extraction well cluster includes nine extraction wells with at least one well in each of the Upper Aquifer A, B1, B2, B3, and B4 zones. This portion of the GWETS began pumping in November 1986. To the north of the Duane Avenue group lies the Carmel Avenue subsystem, which was installed in 1988 and augmented in 1992. The Carmel Avenue group includes five wells distributed among the A, B1, and B2 zones. The Alvarado Avenue subsystem consists of 10 wells across the A, B1, and B2 zones. These wells were installed in 1988 and 1992. The fourth and northernmost line of extraction wells lies along Ahwanee Drive and consists of five wells in the A, B1, and B2 zones. These wells were also installed in 1988 and 1992.

Until October 2010, groundwater from all the Offsite OU extraction wells was conveyed to a treatment system located on the northern side of the building at the nearby AMD 915 Site. The influent groundwater at this facility was first treated using two packed tower air stripper units plumbed in parallel. In October 2010, groundwater extracted from the Offsite OU was permanently diverted to the treatment system at the Signetics Site at 813 Stewart Drive. This treatment system also treats groundwater extracted from the Signetics Site.

The treatment system at the Signetics Site uses an ultraviolet oxidation system as the primary treatment method. The system is sized to remove 100 percent of the influent concentrations of Signetics site chemical contaminants. The ultraviolet oxidation system is also partially effective for Freon 113. A secondary treatment process of air stripping follows the ultraviolet oxidation system. The exhaust from the air stripper is vented to the atmosphere. After these two processes, the treated effluent is discharged to the Sunnyvale East Drainage Channel in accordance with NPDES Permit.

3. Progress Since the Last Five-Year Review

3.1. Previous Five-Year Review Protectiveness Statement and Issues

The protectiveness statements from the 2014 FYR for the AMD and TRW sites stated the following:

> *The remedy at the AMD 901/902 OU currently protects human health and the environment by controlling exposure pathways that could result in unacceptable risks. However, in order for the remedy to be protective in the long-term, the ROD will need to be amended to reflect a revised final groundwater remedy for the Site since the remedy selected in the ROD is no longer operating.*
>
> *The remedy at the TRW OU currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled. Exposure pathways to contaminated groundwater that could result in unacceptable risks are prevented through an*

environmental covenant. The risk due to vapor intrusion is controlled as long as the building remains unoccupied and the exposure pathway remains incomplete. However, in order for the remedy to be protective in the long-term, the ROD will need to be amended to reflect a revised final soil and groundwater remedy for the Site since the remedy selected in the ROD is no longer operating.

A protectiveness determination of the remedy at the Offsite OU cannot be made at this time until further information is obtained. Vapor intrusion assessments must be conducted to determine if indoor air pathways are complete. If unacceptable levels are encountered in a particular building, mitigation plans will be implemented to ensure that levels of VOCs in indoor air are protective. EPA has begun a vapor intrusion assessment and expects that these activities will take approximately two years to complete, at which time a protectiveness determination can be made.

The 2014 FYR included five issues and recommendations.

Table 3. Status of Recommendations from the 2014 FYR

OU	Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
AMD 901/902	The remedy selected for the Site is no longer being operated.	Select a revised cleanup plan and prepare a revised EPA decision document.	Ongoing	A revised Focused Feasibility Study was submitted in 2013. Although alternative cleanup activities have occurred on-site, a revised EPA decision document has not yet been issued.	NA
TRW	The remedy selected for the Site is no longer being operated.	Select a revised cleanup plan and prepare a revised EPA decision document.	Ongoing	A draft Focused Feasibility Study was completed in 2011 that presents cleanup alternatives for the site; the document has been reviewed by EPA but is currently undergoing further revision by the RP. A revised EPA decision document has not yet been issued.	NA
TRW	Groundwater contamination is inadequately characterized in the source area and down-gradient B3 zone.	Add source area and down-gradient B3 zone wells to the suite of annual monitoring wells.	Completed	Northup Grumman mapped the subsurface at the TRW Site using Environmental Sequence Stratigraphy, and three hydrostratigraphic units were identified. In 2017, Northup Grumman installed five additional wells to isolate each unit.	3/29/19

OU	Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
TRW	Increasing chemical contaminant concentrations in down-gradient wells indicates that the remedy is not containing off-site migration.	Investigate and implement optimization options for the ISB to increase down-gradient capture zone groundwater contamination.	Completed	ISB has been successful at reducing concentrations of chemical contaminants in down-gradient wells.	1/2019
Offsite	Groundwater concentrations in the off-site plume indicate a potential for vapor intrusion in an area with 4 schools and over 100 residences. There has been limited indoor air sampling in the area.	Conduct additional vapor intrusion assessments at the Site.	Completed	Multiple indoor air sampling events have been conducted in more than 225 residential households and 40 school buildings, and 20 mitigation systems have been installed to mitigate indoor air TCE concentrations exceeding EPA's short-term and long-term screening levels. Outreach and sampling continue.	NA

3.2. Work Completed at the Site during this Five Year Review Period

Soil

At the TRW Site, Northup Grumman conducted a soil removal action in 2014 within the source area and nearby vicinity to remove residual source materials containing elevated chemical contaminant concentrations impacting groundwater quality. From September through November 2014, Northup Grumman removed approximately 590 tons of chemical contaminant-impacted soil from the source area. EPA did not identify a soil cleanup standard in the ROD; however, remediation criteria were identified for TCE (1,500 micrograms per kilogram [µg/kg]) and cDCE (500 µg/kg) for saturated soils specifically for this removal action.

Groundwater

The effectiveness of remediation activities at the AMD and TRW sites and Offsite OU is limited by continuing contaminant groundwater migration onto the sites from up-gradient sources, including the Signetics Site. To address this issue, the previous FYR recommended the establishment of a broader remedial strategy for regional groundwater restoration. In March 2019, EPA issued of an Administrative Order to Phillips for the Signetics Site to complete a focused Feasibility Study, to evaluate the potential for in-situ groundwater treatment technologies to accelerate the pace of the groundwater cleanup, and hence the cleanup of the adjacent AMD and TRW sites and Offsite OU.

In 2015, Northup Grumman mapped the subsurface within the TRW Site using Environmental Sequence Stratigraphy, in order to identify the primary flow path for the contaminants to migrate through the TRW Site and elucidate the depositional environment of alluvial sediments in the Triple Site area. Numerous hydrostratigraphic unit were identified in the A, B1, and B2 Zones. In 2017, Northup Grumman's consultant installed five additional wells to isolate primary hydrostratigraphic units in the B1 Zone. Two wells (T20B and T21B) were installed to monitor hydrostratigraphic unit 3 along the south and west property boundary. Three additional wells (T22B, T23B, and T24B) were installed along the northwest corner of the property to monitor each of the three primary B1 hydrostratigraphic units, respectively. The updated Conceptual Site Model reassigned well T-9C from the B2 Zone to the B3 Zone that addressed the issue of additional B3 contaminant characterization recommended in the previous FYR.

Vapor Intrusion

Offsite OU

Residential indoor air sampling to detect vapor intrusion in the Offsite OU began in January 2015. As of April 26, 2018, a total of 225 households in 134 buildings were sampled. Additionally, vapor intrusion assessments were conducted starting in January 2015 for the four schools within the Offsite OU. The data from these sampling events are further described in Section 4.2.3.

Mitigation efforts, when needed have been installed and have consisted of installation of sub-slab or sub-membrane depressurization systems, ventilation upgrades, conduit sealing, installation and operation of indoor air purifiers, Operations & Maintenance (O&M) measures, and post-mitigation confirmatory indoor air sampling to confirm success of mitigation measures at achieving protective levels of TCE. Two residences have denied access to install mitigation systems, and one residence denied access to allow sampling. EPA continues to work with these owners to allow access.

TRW

A Vapor Intrusion Evaluation Report was completed for the TRW Site in June 2015. This report summarized the vapor intrusion mitigation procedures conducted and the results of the confirmatory indoor air sampling. Mitigation activities included:

- additional former source area excavations to remove residual contaminated mass;
- installation of a passive sub-slab vapor collection system and repairs verified by a California-registered engineer;
- closure of potential conduits for the vapor intrusion pathway, including the interior groundwater monitoring wells;
- sealing of other potential vapor intrusion conduits, including slab piping penetrations, gaps between interior walls where soil is exposed, and expansion joints in the concrete slab;
- clean-out and visual inspection of the elevator shaft to verify its integrity; and
- confirmatory sub-slab and indoor air (10-hour TO-15 canister) sampling under ventilation-off conditions.

The most recent round of indoor air sampling at the TRW Site confirmed protective levels of TCE – levels of up to 0.58 µg/m3 – below EPA's long-term commercial Regional Screening Level (RSL) of 2

µg/m3 and EPA Region 9's Interim Accelerated Response Action Level of 7 µg/m3 (10-hour workday). These indoor air concentrations meet EPA's requirements for being protective of public health under a commercial-use scenario and demonstrate that the building is acceptable for occupancy.

AMD

A vapor intrusion evaluation was conducted by AMD in March 2013 the former AMD facility located at 901/902 Thompson Place. Indoor air samples were collected inside the building with the HVAC system deactivated to evaluate potential "worse-case" conditions. In 2014, AMD re-evaluated the data collected in 2013 to ensure to ensure consistency with USEPA's recent draft guidance and guidelines. AMD concluded that since vapor intrusion does not appear to be occurring based on the analysis, and since chemical concentrations in groundwater have been following decreasing trends, future vapor intrusion risk to the on-property building is very low.

4. Five-Year Review Process

4.1. Community Notification and Site Interviews

A public notice was made available in the *Sunnyvale Sun* on May 10, 2019 stating that there was a Five-Year Review and inviting the public to submit any comments to the EPA. The results of the review and the report will be made available at the information repository for each site uploaded to each site's webpage at:

AMD Site: https://www.epa.gov/superfund/advancedmicrodevices
TRW Site: https://www.epa.gov/superfund/trwmicrowave
Offsite OU: https://www.epa.gov/superfund/triplesite

During the FYR process, interviews were conducted to document any perceived problems or successes with the remedy that has been implemented to date. The results of these interviews are summarized below.

The communications officer for the City of Sunnyvale was interviewed. This individual expressed that the EPA team had been very receptive to City officials and their input and had been timely in notifying residents with developing site information. No issues or concerns with respect to the cleanup were raised.

The Environmental Health and Safety Manager for AMD was also interviewed. This individual expressed that the project approach is completing the necessary work to protect human health and the environment and allow for continued use of the AMD property. Communication with EPA has been sufficient and the company does not have any concerns. It was also noted that an individual was found camping in the treatment system compound in 2017, but no damage or theft was noted. The police were notified and they assisted with removal of the individual's possessions from the compound, and no further action was required.

Finally, the principal of San Miguel Elementary School was interviewed. The principal expressed overall positive sentiments towards EPA and the progress of the indoor air investigation and groundwater cleanup. The principal noted a positive relationship with EPA and that the school has felt well informed.

One suggestion shared with EPA was to be informed further in advance of when any sampling events were to occur at the school.

The full list of interview questions and responses can be found in Appendix E.

4.2. Data Review

The data review for this FYR focused on data collected during the past five years (2014 through 2018) from monitoring reports, quarterly reports, and other associated reports provided to EPA. The following sections are organized by soil, groundwater, and vapor intrusion for each site or OU to evaluate the effectiveness of the ROD remedies during the review period.

4.2.1. Soil

The completion of the soil removal action at the TRW Site during the review period (2014 – 2018) should reduce VOC impacts to groundwater in the source area. Twelve of 39 sample locations from the excavated materials contained concentrations of TCE and/or cDCE above the remediation criteria. Confirmation samples were collected from the side-walls of the excavation to confirm the contaminant levels remaining, with soils showing TCE and cDCE levels above the remediation criteria remaining in place at depths of 25 feet or greater (Northrop Grumman, 2015). Two exceptions included samples SB-8 and SB-9, which were advanced at an angle below the building footing and were not practicable to excavate.

4.2.2. Ground Water

4.2.2.1 AMD 901/902 Thompson Place Site

The ISB program has been effective in all groundwater treatment zones at the AMD Site. TCE concentrations have decreased significantly since treatment. Breakdown products from TCE, including cDCE and vinyl chloride, are evident. The majority of contaminant mass is contained in the A and B1 zones. AMD's ISB program is successful in reducing chemical contaminants, and chemical contaminant concentrations are lower at the downgradient property boundary than the upgradient property boundary, indicating that containment of the contaminants is occurring.

Contaminated groundwater from the Signetics Site to the west likely influences groundwater concentrations at the AMD Site. The groundwater direction for the A, B1, B2, and B3 zones remains to the north-northeast, and GWETS operation at the Signetics Site does not appear to shift groundwater flow back toward the west, thus contaminated groundwater from the Signetics Site likely flows onto the AMD Site. Freon 113, which was used at the Signetics Site but not at the AMD Site, has been found in AMD well 37-S.

Fluctuations in groundwater elevation range from 3 to 5 feet in all shallow aquifers, typical of seasonal variation and operation of the nearby GWETS. The current vertical gradient between the shallow aquifers (A, B1, and B2) is upward. Stable TCE trends at concentrations below the MCLs in the underlying B3 zone confirm vertical containment of the plume and upward gradients.

Table 4. AMD Groundwater Concentration Data

Concentrations reported in micrograms per liter (µg/L)

Well ID	TCE		cDCE		Vinyl Chloride		Mole Fraction Ethene & Ethane[3]
	Start of ISB (2005)	Most Recent (2018)	Start of ISB (2005)	Most Recent (2018)	Start of ISB (2005)	Most Recent (2018)	2018
A Zone							
16-S	6.1[2]	<0.50[3] (-100%)[4]	29	3.0 (-90%)	37	29 (-22%)	28%
23-S	37	38 (+3%)	84	42 (-50%)	31	0.60 (-98%)	3.0%
28-MW	10	<0.50 (-100%)	26	0.71 (-97%)	28	14 (-50%)	60%
DW-2	3.0[5]	<0.50[6] (-100%)	110	<0.50 (-100%)	<0.7	<0.50 (0%)	100%
X2A	200	<5.0 (-100%)	230	49 (-79%)	62	980 (+1,481%)	11%
B1 Zone							
16-D	740	<0.50[7] (-100%)	970	2.1 (-100%)	45	7.7 (-83%)	98%
23-D	230	290 (+26%)	390	3.7 (-99%)	56	<2.5 (-100%)	0.057%
PMW-2-1	82	<50 (-100%)	6,700	4,800 (-28%)	2,300	430 (-81%)	4.9%
DW-1	440	<0.50[8] (-100%)	3,700	0.78 (-100%)	32	3.0 (-91%)	96%
DW-7	300	69 (-77%)	100	130 (+30%)	4.6	4.3 (-7%)	0.26%
X1B	360	<10 (-100%)	1,600	300 (-81%)	120	140 (+17%)	3.5%
X2B1	420	150 (-64%)	420	110 (-74%)	41	7.8 (-81%)	5.4%
B2 Zone							
PMW-2-3	290	270 (-7%)	440	75 (-83%)	24	11 (-54%)	1.3%

4.2.2.2 TRW Microwave Site

Progress at the TRW Site is slow despite soil removal actions and enhanced anaerobic biodegradation (EAB) treatment because contaminant concentrations are influenced by upgradient contaminated groundwater sources, including the Signetics Site. Groundwater contaminant concentrations throughout the TRW Site have remained consistent or decreased slightly during the review period. A and B1 zone TCE concentrations dropped significantly after the EAB program began in 2000. Prior to the 2014 source area soil excavation at the TRW Site, the source area contained the highest concentrations of contaminants. Following excavation, the highest concentrations at the TRW Site are located either up-gradient or cross-gradient to the source area. In general, chemical contaminant concentrations decrease as groundwater moves northward through the TRW Site. In addition, Freon 113, which was not used at the TRW Site but was used at the Signetics Site, was found in on-site wells. Isotope testing during the EAB pilot test indicates that the EAB pilot test is effective in treating source area contamination, but that off-site migration of contaminants onto the site influences the downgradient plume.

Subsurface investigations at the TRW Site in 2015 and 2016 using Environmental Sequence Stratigraphy identified numerous hydrostratigraphic units present in the A, B1, and B2 aquifer zones – underground channels through which groundwater can flow. Hydrostratigraphic unit 1 is hydraulically linked to the TRW source area. Hydrostratigraphic unit 2 is a slightly deeper unit, hydraulically linked to off-site sources. Hydrostratigraphic units 3 is at a shallower depth than hydrostratigraphic units 1 and 2. At the time of the investigation, hydrostratigraphic unit 3 was not being monitored by any existing wells. In 2017, the Northrop Grumman's consultant installed five additional wells to monitor each hydrostratigraphic unit. Two wells were installed to monitor hydrostratigraphic unit 3 along the south and west property boundary, respectively. Three wells were installed along the northwest corner of the property to monitor hydrostratigraphic units 1, 2, and 3, respectively.

The groundwater flow directions for the A, B1, and B2 zones at the TRW Site range from the north to the north-northeast. However, the hydrostratigraphic units within the aquifer zone can also modify the flow pathway on a local scale. Another factor influencing groundwater flow direction is the operation of the groundwater extraction and treatment systems (GWETSs) at two adjacent sites (Signetics and AMD 915).

Table 5. TRW Groundwater Concentrations Trends

TRW Well ID	GW Zone	Analyte	n	Coefficient of Variation (COV)	MK Statistic (S)	Confidence Factor (%)	2017 Concentration	Trend
Upgradient Wells								
T-7A	A	TCE	11	0.4	-11	77.7	160	Stable
		cDCE	11	0.55	12	79.9	84	No Trend
T-7B	B1 HSU1	TCE	10	0.38	-8	72.9	190	Stable
		cDCE	10	0.4	-4	59	12	Stable
Source Area Wells								
T-14A	A	TCE	16	0.96	8	62.2	55	No Trend
		cDCE	16	0.33	49	98.6	55	Increasing
T-8B	B1 HSU3	TCE	11	0.78	-32	99.4	5	Decreasing
		cDCE	11	0.74	11	77.7	420	No Trend
T-12C	B2	TCE	10	1	-13	85.4	140	Stable
		cDCE	10	1.18	-11	81	6.3	No Trend
Downgradient Wells								
T-9A	A	TCE	11	0.16	-1	50	48	Stable
T-16A	A	TCE	10	0.32	1	50	59	No Trend
		cDCE	10	0.14	13	85.4	72	No Trend
T-10B	B1 HSU1	TCE	10	0.54	-19	94.6	<0.5	Probably Decreasing
		cDCE	10	0.55	19	91.8	150	Probably Increasing
T-11C	B2	TCE	10	0.84	10	78.4	310	No Trend
		cDCE	10	0.8	10	78.4	26	No Trend
Cross gradient Well								
T-17B	B1 HSU2	TCE	13	0.58	3	54.8	210	No Trend
		cDCE	13	0.37	23	88.3	370	No Trend

4.2.2.3 Offsite OU

Groundwater restoration within the Offsite OU did not progress substantially towards reaching the RAO of groundwater restoration within the review period. During the review period, dissolved concentrations of TCE, cDCE, and vinyl chloride exceeded MCLs in one or more zones of the shallow aquifer, and Mann-Kendall analysis indicates that TCE concentrations in all aquifer zones are stable or decreasing (Appendix B), however concentrations throughout the Offsite OU are elevated one or two orders of magnitude above ROD remediation level of 5 mg/L. While there is a current trend of decreasing concentrations in several wells, the projection for aquifer restoration will be in 2060-2080 timeframe; this is well beyond the ROD-estimated projected restoration time of 2027.

Table 6. Linear projections for OOU reaching ROD Remediation Levels for TCE

Well	Projected Year Cleanup
S077A	2080 (approx.)
COM39A	2050
COM60B1	2060
S077B1	2043
COM06B2	2080 (approx.)
COM60B2	2080 (approx.)

While recognizing there is a high potential for subsurface complexities at the Offsite OU, the current understanding of the subsurface is simplified and does not account for the potential for highly channelized flow. Greater detail of the subsurface is needed to identify and adequately map the potential migration pathways such that the Offsite OU plume geometry, configuration, and chemical content can be better understood and adequately remediated.

The remedy appears to be providing hydraulic control of contaminant migration in groundwater from upgradient sources and preventing further downgradient migration in the B1 and deeper aquifer zones. It is unclear if vertical containment is occurring due to the complexities of the subsurface and the elevated concentrations. The concentration footprint of the plume has not significantly changed within the review period indicating containment is occurring. The groundwater flow direction at the eastern portion of the plume has changed following startup of the AMD 915 Site extraction wells, possibly indicating limited or incomplete capture along the eastern property boundaries.

Table 7. Off-site Operable Unit Groundwater Concentration Trends

Well ID	GW Zone	n	Coefficient of Variation	MK Statistic	Confidence Factor (%)	2017 TCE Concentration (ug/l)	Trend
Southern Portion of Plume (downgradient of Signetics)							
S075A2	A	11	0.62	-28	98.4	140	Decreasing
S057B	B1	11	2.42	-35	99.7	1	Decreasing
Duane Avenue							
COM06A	A	11	0.19	-27	98	180	Decreasing
COM06B2	B2	11	0.15	-10	75.3	540	Stable
COM09B3	B3	11	0.13	-25	97	580	Decreasing
Center of Plume South of San Miguel School							
COM01A	A	11	0.47	-10	75.3	29	Stable
COM01B1	B1	11	0.16	-17	89.1	130	Stable
COM01B2	B2	11	0.1	-11	77.7	210	Stable
Center of Plume East of San Miguel School							
COM04A	A	11	0.13	-22	94.9	26	Probably decreasing
Blythe Avenue - west San Miguel School - Offsite							
COM55A	A	11	0.34	-5	61.9	14	Stable
Center of Plume North of San Miguel School							

Well ID	GW Zone	n	Coefficient of Variation	MK Statistic	Confidence Factor (%)	2017 TCE Concentration (ug/l)	Trend
COM03A	A	11	0.1	-17	89.1	120	Stable
COM03B	B1	11	0.1	-17	89.1	57	Stable
COM03B2	B2	11	0.11	8	70.3	250	No Trend
COM06B3	B3	11	0.1	-23	95.7	440	Decreasing
COM06B4	B4	11	0.24	-3	56	89	Stable
Furthest downgradient & Offsite							
COM63-B1	B1	11	0.59	-46	99.9	22	Decreasing

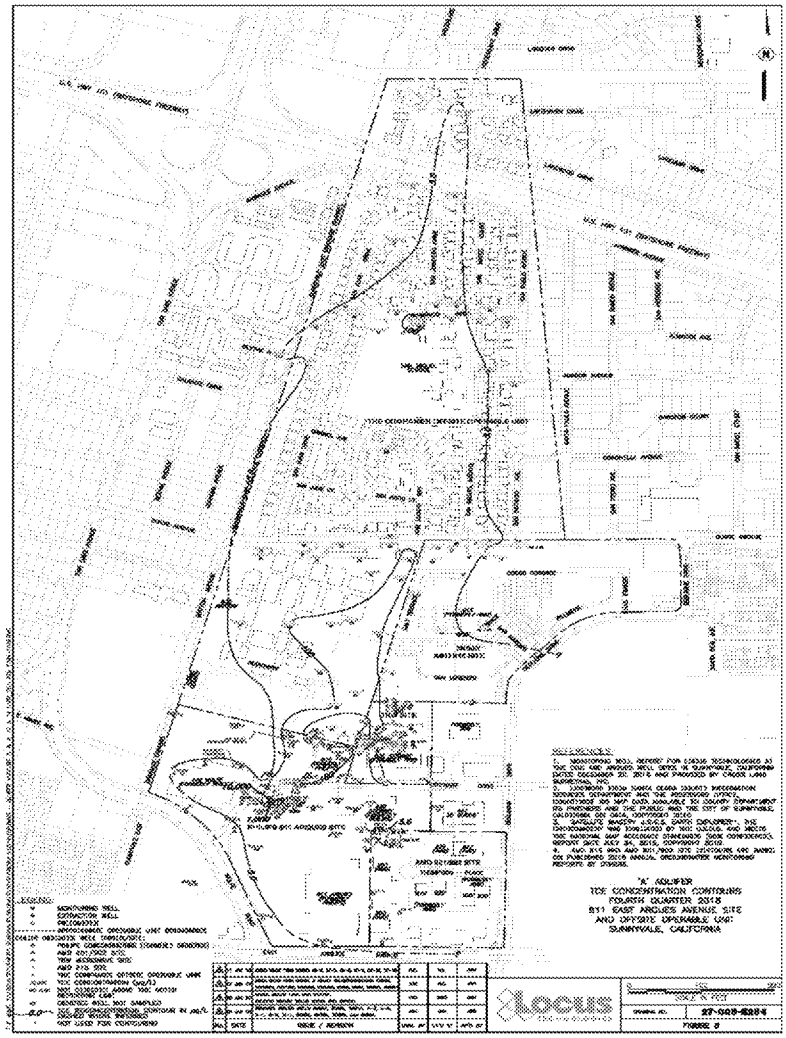


Figure 5. A Zone Aquifer TCE Concentrations at AMD, TRW, Signetics, and Offsite 2018

4.2.3. Vapor Intrusion

On August 11, 2014, EPA issued a Notice of Delinquency to the companies responsible for the AMD, TRW, and Signetics sites and Offsite OU regarding vapor intrusion. Philips's previous investigations in the Offsite OU, initiated in 2004 and limited in scope, did not show TCE levels of concern in the indoor locations sampled. In 2015, EPA issued an Administrative Order to Philips requiring comprehensive indoor air investigations and mitigation efforts at all four neighborhood schools and all residential buildings within the Offsite OU. These efforts are ongoing as of the writing of this FYR. To date, more than 225 residences and 40 school buildings have been sampled, and 20 mitigation systems have been installed in homes and classrooms to address findings of unacceptable TCE in indoor air. EPA also oversaw vapor intrusion assessment and mitigation efforts in commercial buildings at the AMD and TRW sites. The findings are summarized below.

4.2.3.1 TRW Microwave Site

Northrop Grumman completed a vapor intrusion assessment at the TRW Site in June 2015. Indoor air samples were collected under ventilation-on and -off conditions, which showed exceedances of EPA's health-protective screening levels for commercial buildings. To reduce the potential for vapor intrusion, Northrop Grumman subsequently completed a soil excavation of residual materials within the source area and removed interior monitoring wells prior to the redevelopment of the one on-site building. Potential conduits for vapor intrusion were sealed, including piping penetrations through the slab, expansion joints, and gaps between interior walls where soil is exposed. In addition, a passive sub-slab vapor collection system was installed, with the capability of being converted to an active, pumping system in the future, if necessary.

Post-mitigation sampling following these efforts showed TCE concentrations of up to 0.58 micrograms per cubic meter ($\mu g/m^3$) in indoor air samples, below EPA's long-term commercial RSL of 3 $\mu g/m^3$ and EPA Region 9's Interim Accelerated Response Action Level of 7 $\mu g/m^3$ (for a 10-hour workday). These indoor air concentrations meet EPA's requirements for being protective of public health under a commercial-use scenario and establish that the building is acceptable for occupancy.

4.2.3.2 AMD 901/902

A vapor intrusion evaluation was conducted by AMD in March 2013 the former AMD facility located at 901/902 Thompson Place. Indoor air samples were collected inside the building with the HVAC system deactivated to evaluate potential "worse-case" conditions. Six VOCs (PCE, TCE, cDCE, 1,4-DCB, 1,1,1-trichloroethane, and Freon 113) were detected in at least one indoor air sample. All detections were at concentrations less than their RSLs, with the exception of the common household chemical 1,4-DCB, which was detected at concentrations greater than its RSL. Based on the current use of the building as a storage facility, the presence of 1,4-DCB found in mothballs, mildew prevention products, or other such products in storage units would be expected.

In 2014, AMD re-evaluated the data collected in 2013 to ensure to ensure consistency with USEPA's recent draft guidance and guidelines. AMD concluded that since vapor intrusion does not appear to be occurring based on the analysis, and since chemical concentrations in groundwater have been following decreasing trends, future vapor intrusion risk to the on-property building is very low.

4.2.3.3 Offsite OU Residences

Residential indoor air sampling in the Offsite OU under EPA oversight began in January 2015 and is ongoing. As of April 26, 2018, a total of 225 households in 134 buildings were sampled. Sampling data was organized into five groups (Groups 1 through 5, Appendix B) that relate the TCE indoor air sampling results and building location to the underlying TCE groundwater plume. The TCE plume is defined by the area where TCE levels in groundwater exceed the EPA's MCL of 5.0 µg/L. Sampling data was compared to EPA's long-term residential RSL for indoor air of 0.48 µg/m^3 and EPA's short-term residential RSL of 2.0 µg/m^3. Multiple lines-of-evidence were used to determine if the TCE levels detected were due to vapor intrusion, attributable to elevated outdoor air TCE levels, or related to a confounding indoor source of TCE.

Group 1 households (which total 33) are in buildings located *outside* of the shallow groundwater TCE plume, based upon the current data set, and defined by the MCL of 5.0 µg/L, but *within or in very close proximity to the Offsite OU* as it is defined in the ROD. Group 1 residences show *no evidence of vapor intrusion*, i.e., have TCE results less than the long-term screening level of 0.48 µg/m^3, or TCE results between 0.48 and the short-term screening level of 2.0 µg/m^3, but likely non-vapor intrusion related, for example, attributable to elevated outdoor air TCE levels or an indoor source.

Similar to Group 1, Group 2 households (which total 97) are in buildings showing *no evidence of vapor intrusion.* However, Group 2 residences are located *directly over* the shallow groundwater TCE plume.

Group 3 households (which total two) are in buildings located *directly over* the groundwater TCE plume with indoor air TCE results *showing some evidence of vapor intrusion, but within EPA's Superfund health-protective risk management range* of 0.48 to 2.0 µg/m^3.

Residences falling within Groups 1 through 3 have been identified by EPA as warranting no further action with respect to the vapor intrusion pathway.

Group 4 households (which total 31) are in buildings located *directly over* the groundwater TCE plume with TCE results *showing evidence of unacceptable vapor intrusion, exceeding the short-term screening level of 2 µg/m^3, warranting mitigation*. For these buildings showing a need for mitigation, TCE in the nearest shallow groundwater monitoring wells was detected at levels of 20 – 30 µg/L and above. Mitigation efforts at these buildings have been completed, specifically, installation of active sub-slab and sub-membrane depressurization systems and post-mitigation sampling and maintenance plans to confirm continued effectiveness of the mitigation systems. Interim mitigation measures have also included the installation of air purifiers, conduit sealing, and one-way floor drains.

Group 5 households (which total 62) are in buildings located *directly over* the groundwater TCE plume where *preemptive mitigation has been completed or is currently under consideration* to address potential unacceptable vapor intrusion. Similar to Group 4 residences (which showed evidence of unacceptable vapor intrusion), Group 5 residences are also located in *close proximity* to shallow groundwater monitoring wells showing TCE at levels of 20 – 30 µg/L and above. TCE results in Group 5 residences were either elevated as compared to outdoor air TCE levels, showing some evidence of vapor intrusion, but less than the short-term screening level of 2.0 µg/m^3 or in close proximity to and of similar construction to a Group 4 building.

4.2.3.4 Offsite OU Schools

Indoor air sampling at school buildings in the Offsite OU under EPA oversight began in January 2015 and is ongoing. A total of four schools, including 40 buildings, have been sampled under both heating and ventilation systems (HVAC)-off and HVAC-on conditions (Appendix B). Unacceptable levels of vapor intrusion were detected in eight school buildings, at which mitigation measures were implemented to prevent elevated levels of TCE vapors from accumulating indoors. In addition, preemptive mitigation systems were installed in four school buildings, three of which were new buildings where the mitigation systems were integrated into the new construction.

Mitigation measures in school buildings included the installation of active, sub-slab and sub-membrane depressurization systems, placement of indoor air purifiers, upgrades and operational modifications to HVAC systems, conduit sealing, installation of one-way floor drains, and post-mitigation sampling and maintenance plans to confirm continued effectiveness of the mitigation systems.

4.2.3.5 Outdoor Air

Sampling of ambient outdoor air (which occurs during each indoor air sampling event) has occurred regularly in the Offsite OU since January 2015. The results of this outdoor air sampling have shown varying levels of TCE with a general upward trend. Data received more recently in May 2019 from Philips showed outdoor air TCE levels of up to 3.6 µg/m^3 during the October 2018 and January 2019 sampling events at the Signetics Site (where the treatment system for the AMD and TRW sites and Offsite OU TCE groundwater plume is located and where a sub-slab depressurization system has recently been installed at a commercial-type building. (Figure 6) While the highest outdoor air TCE measurements have generally been observed in the November – January timeframe, these spikes appear to be increasing over time.

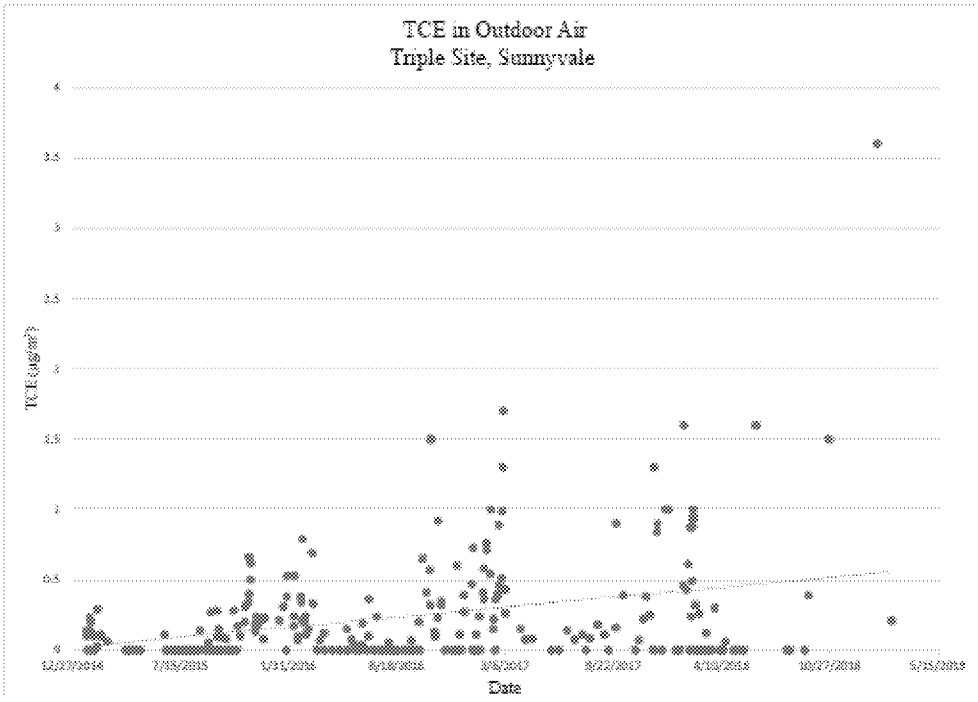


Figure 6. TCE Concentrations in Outdoor Air

4.3. Site Inspection

The inspection of the AMD and TRW sites and Offsite OU was conducted on March 14, 2019. In attendance were Melanie Morash, EPA, Benino McKenna, USACE, and personnel and contractors from AMD, Northrop Grumman Systems Corporation, and Philips; see Appendix F for full list. The purpose of the inspection was to assess the protectiveness of the remedy.

The participants completed a site walk, visiting all three sites, as well as the Signetics Site. The GWETS at the Offsite OU and Signetics Site appeared to be in good condition. Associated site extraction and monitoring wells were observed throughout all the sites, and all appeared to be in good condition. Injection wells for the EAB remediation were viewed at the TRW Site, as well as ISB injection wells at the AMD Site. All injection wells appeared to be in good condition and functioning properly.

The full trip report and photographs can be viewed in Appendix F.

5. Technical Assessment

5.1. Question A: Is the remedy functioning as intended by the decision documents?

The groundwater extraction and treatment remedies, and the addition of in-situ pilot tests at the AMD and TRW sites have resulted in significant decreases in concentrations of chemical contaminants since operation began. Currently, the systems at the AMD and TRW sites are not being operated, and in-situ bioremediation is being implemented to further cleanup contaminants. These in-situ efforts, combined with the institutional controls currently being implemented at the AMD and TRW sites, and the mitigation system in place at the TRW site, are providing protectiveness. Achievement of cleanup goals will remain a challenge as long as the migration of these chemical contaminants from upgradient sources at the Signetics Site persists.

The selected remedy for the Offsite OU is currently in operation and is functioning as intended with regard to controlling contaminant migration in groundwater. Groundwater restoration within the Offsite OU has not progressed substantially towards reaching the RAO of groundwater restoration within the review period. While there is a current trend of decreasing concentrations in several wells, the projection for aquifer restoration will be in 2060-2080 timeframe; this is well beyond the ROD-estimated projected restoration time of 2027.

A 2005 environmental covenant for the AMD Site prohibits residential development; construction or use of medical facilities, day-care centers, or schools; or use of groundwater or excavation of soils without prior approval of the Regional Board. No activities were observed at the AMD Site that violate the covenant. However, this 2005 environmental covenant does not comply with Civil Code section 1471. A new covenant which complies with Civil Code section 1471 and addresses vapor intrusion should be recorded after the new remedy is selected.

A 1992 covenant and agreement for the TRW Site prohibits the use of groundwater; use of property for day-care; or excavation of soils without prior approval of the Regional Board until cleanup levels are achieved. No activities were observed at the TRW Site that violate the covenant.

The ROD does not require institutional controls to prevent use of the shallow groundwater for the Offsite OU, however the Santa Clara Valley Water District (SCVWD) regulates the construction, destruction, and maintenance of wells in the Santa Clara County under Ordinance 90-1; well installations are prohibited without a permit from the SCVWD.

5.2. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

No, the exposure assumptions used at the time are not still valid. The vapor intrusion pathway is complete and was not included in the ROD.

Indoor air sampling was conducted within the last five years. Results from these sampling events indicate that the vapor intrusion pathway is complete in buildings in the Offsite OU. Wherever TCE levels have been measured in indoor air above health-protective screening levels, mitigation systems have been installed where property owners have granted access. All school buildings with measured indoor air exceedances of EPA's health-protective screening levels have been provided with mitigation systems. EPA is working with the Philips on a supplemental school sampling plan and a residential preemptive mitigation framework to guide future response work and reduce the extent of back-and-forth sampling.

Vapor intrusion was also evaluated in the AMD and TRW sites (in 2014 and 2015 respectively). The vapor intrusion evaluation at the AMD Site showed no evidence of potential indoor air exposures due to groundwater contamination. Vapor intrusion evaluations performed at the TRW Site indicated that TCE concentrations in indoor air near the former source area posed an inhalation risk. These risks were addressed via the mitigation activities completed in 2015. Indoor air confirmation sampling conducted subsequent to these mitigation activities confirmed the effectiveness of these measures.

However, investigation of potential TCE impacts to outdoor ambient air from the groundwater treatment system for the AMD and TRW sites and Offsite OU, which is located within the Signetics Site, is warranted, as well as potential impacts from emissions from the residential, school, and commercial vapor intrusion mitigation systems that have been installed to address inhalation risks.

There have been no changes to ARARs (Appendix C) that would affect the protectiveness of the groundwater remedy for the AMD and TRW sites and Offsite OU. Groundwater cleanup standards have not changed since the ROD was issued. No new contaminants have been identified since the ROD.

Land use has not changed at the AMD and TRW sites and Offsite OU since the last FYR. An environmental covenant and a covenant and agreement for the AMD and TRW sites, respectively, are in place that prohibits installation of groundwater wells for domestic use at the AMD and TRW sites.

5.3. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no other information known at this time that calls into question the protectiveness of the remedy.

6. Issues/Recommendations

Table 8. Issues and Recommendations Identified in the Five-Year Review

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): AMD Site	Issue Category: Remedy Performance			
	Issue: The remedy selected for the AMD Site is no longer being operated and does not address vapor intrusion.			
	Recommendation: Select a revised remedy which also addresses potential vapor intrusion in the event of future land use changes.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/1/2022
OU(s): TRW Site	Issue Category: Remedy Performance			
	Issue: The remedy selected for the TRW Site is no longer being operated.			
	Recommendation: Select a revised remedy which incorporates long-term stewardship measures for the current vapor intrusion mitigation measures in place, as well as addresses potential vapor intrusion in the event of future land use changes.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/1/2022
OU(s): Offsite OU	Issue Category: Remedy Performance			
	Issue: Outdoor air TCE levels have shown a generally upward trend over time since regular sampling commenced in January 2015.			
	Recommendation: Investigate contributions to outdoor air TCE levels from fugitive emissions from the groundwater treatment system and emissions from the vapor intrusion mitigation systems.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/1/2022
OU(s): Offsite OU	Issue Category: Remedy Performance			
	Issue: The remedy selected for the Offsite OU will not be able to achieve the remedial action objective of restoration of groundwater in a reasonable timeframe, as defined in the ROD.			

	Recommendation: Conduct remedy performance optimization efforts, after investigating whether hydrogeology is adequately characterized. A revised remedy may be needed to achieve the RAOs.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/1/2022
OU(s): Offsite OU	Issue Category: Changed Site Conditions			
	Issue: Indoor air sampling results indicate that the vapor intrusion pathway is complete in buildings in the Offsite OU			
	Recommendation: Select a revised remedy which addresses vapor intrusion.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	PRP	EPA	9/1/2022

7. Protectiveness Statement

Table 9. Protectiveness Statement

Protectiveness Statement(s)	
Operable Unit: AMD Site	*Protectiveness Determination:* Short-term Protective
Protectiveness Statement: The remedy at the AMD Site currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled and there is no evidence of unacceptable vapor intrusion for the current commercial land use. However, in order for the remedy to be protective in the long-term, a revised final groundwater remedy for the AMD Site should be selected, as the remedy selected in the 1991 ROD is no longer operating. The revised remedy should also address potential vapor intrusion in the event of future land use changes, as vapor intrusion was not addressed in the 1991 ROD and record a new environmental.	

Protectiveness Statement(s)	
Operable Unit: TRW Site	*Protectiveness Determination:* Short-term Protective
Protectiveness Statement: The remedy for the TRW Site currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled. Exposure pathways to contaminated groundwater that could result in unacceptable risks are prevented through a covenant and agreement. The risk due to vapor intrusion for the current commercial land use has been addressed. However, in order for the remedy to be protective in the long-term, a revised soil and groundwater remedy for the TRW Site should be selected, as the remedy selected in the ROD is no longer operating. The revised remedy should also address vapor intrusion assessment and response procedures to ensure the long-term stewardship of the vapor intrusion mitigation measures currently in place, as well as potential vapor intrusion in the event of future land use changes, as vapor intrusion was not addressed in the 1991 ROD.	

Protectiveness Statement(s)	
Operable Unit: Offsite OU	*Protectiveness Determination:* Short-term Protective
Protectiveness Statement: The remedy for the Offsite Operable Unit currently protects human health and the environment because exposure pathways for soil and groundwater are being controlled. The risk due to vapor intrusion for the current residential use is being addressed through installation of mitigation measures. However, in order for the remedy to be protective in the long-term, a remedy performance optimization and updated site conceptual model is needed. A revised remedy is needed to achieve the RAOs and to address vapor intrusion assessment and response procedures to ensure the long-term stewardship of the vapor intrusion mitigation measures currently in place. Finally, an investigation of the contributions to outdoor air TCE levels from fugitive emissions from the groundwater treatment system and emissions from the vapor intrusion mitigation systems is needed.	

8. Next Review

The next FYR report for the AMD Site, the TRW Site and the Offsite OU is required five years from the completion date of this review.

Appendix A: List of Documents Reviewed

General/Other

EPA, 1991. Record of Decision, Advanced Micro Devices #901/902, Signetics, TRW Microwave. Combined Superfund Sites, Sunnyvale, California, September 11, 1991.

EPA, 2008, A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems, January.

EPA, 2014. Fourth Five-Year Review Report for Advanced Micro Devices 901/902 & TRW Microwave Superfund Sites. September 30th, 2014.

EPA, 2017, Best Practices for Environmental Site Management A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models, September.

AMD 901/902

Haley Aldrich, 2018. Second Quarter 2018 Progress Report for the In-Situ Bioremedation Program at Former 901/902 Thompson Place. July 2018.

Haley Aldrich, 2018. Combined 2017 Annual Groundwater Monitoring Report and Annual In-Situ Bioremediation Program Report, Former 901/902 Thompson Place. January 31, 2018.

Haley Aldrich, 2017. Combined 2016 Annual Groundwater Monitoring Report and Annual In-Situ Bioremediation Program Report, Former 901/902 Thompson Place. January 31, 2017.

Haley Aldrich, 2016a. Soil Excavation and Removal Report. December 14, 2016.

Haley Aldrich, 2016b. Combined 2015 Annual Groundwater Monitoring Report, Former 901/902 Thompson Place. January 27, 2016.

Haley Aldrich, 2014. Vapor Intrusion Evaluation Report 915 Deguine Drive, February 28, 2014.

Stantec, 2017. Vapor Mitigation Plan, The Vale Development Project, Former Spansion Facility. March 20, 2017.

TRW

AECOM, 2018. 2017 Annual Groundwater Monitoring and Remedial Progress Report. May 3, 2018.

AECOM, 2016, Conceptual Site Model, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California, April 19.

AECOM, 2016, Background Water Quality Evaluation Report, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California, November.

Northrop Grumman, 2018. Well Installation Report Former TRW Microwave Site. May 2018.

Northrop Grumman, 2017. Well Installation Work Plan Former TRW Microwave Site. April 19, 2017.

Northrop Grumman, 2015. Source Area Soil Removal Report Former TRW Microwave Site. March 20, 2015.

Offsite OU

Aptim Federal Services, LLC, 2019. Vapor Intrusion Data Review – Residential Buildings, technical memorandum. February 6, 2019.

Aptim Federal Services, LLC, 2019. Vapor Intrusion Data Review – School Buildings, technical memorandum. February 6, 2019.

Locus Technologies, 2018. Annual Groundwater Monitoring Report January to December 2017. January 30, 2018.

Locus Technologies, 2017. Annual Groundwater Monitoring Report January to December 2016. January 30, 2018.

Locus Technologies, 2016. Annual Groundwater Monitoring Report January to December 2015. January 26, 2018.

Locus Technologies, 2015. Annual Groundwater Monitoring Report January to December 2014. January 30, 2015

Locus Technologies, 2011. Annual Groundwater Monitoring Report January to December 2010. January 28, 2011 .

Signetics (Philips) OU

Emcon, 1996, Subsurface Investigation Report, 440 North Wolfe Road and 811 East Arques Avenue Facilities, Philips Semiconductors, Sunnyvale, California, September 5.

Locus Technologies, 2016. Five-Year Status Report and Remedial Effectiveness Evaluation 2011 to 2015. June 17, 2016.

Appendix B: Data Review

Groundwater

AMD 901/902 Thompson Place Site

The groundwater monitoring program at the AMD Site OU (also known as AMD 901/902) consists of two parts: 1) the annual site-wide groundwater monitoring sampling program and 2) quarterly groundwater samples to assess the effectiveness of the ISB and selected modifications. The data review utilized the annual groundwater data from 2014 to 2018 for the AMD Site (Haley Aldrich, 2015, 2016, 2017, 2018). Annual groundwater data indicate that four chemical contaminants (TCE, cDCE, tDCE, and vinyl chloride) remain at levels above cleanup standards at the site in the A, B1, and B2 zones (Table B-1). Twenty-one wells have been sampled with 15 of these wells exceeding the Maximum Contaminant Levels (MCLs). The majority of the contaminant mass is contained in the A and B1 zones.

ISB Program summary

The ISB program is reducing concentrations in the majority of wells monitored in the A, B1 and B2-zone aquifers. Source area concentrations have been reduced to below the MCLs for half of the wells in the area (Table B-2). Breakdown products are present in most A-zone wells indicating successful ISB treatment.

A Zone

The ISB program has been effective within the A zone. Concentrations within the source zone (wells 16-S, 22-S, 23-S and 28-S) have significantly declined since ISB startup, and breakdown products of TCE, including cDCE and vinyl chloride, are evident on the time series plots. An effective ISB remediation system observes temporary increases in concentration in the breakdown products (such as cDCE and vinyl chloride) as they degrade to benign end products (ethene, ethane). Increases in vinyl chloride concentrations suggest anaerobic bioremediation is occurring within the A zone. If the ISB program continues to maintain a microbial population and beneficial environment for anaerobic degradation, progress towards meeting the RAO of preventing off-site contaminant migration.

The direction of groundwater flow in the A zone is towards the north-northeast, indicating contaminated groundwater from the Signetics Site is migrating on the AMD Site (Figure B-2). The presence of cDCE and Freon 113 utilized at Signetics suggests that the Signetics and AMD groundwater plumes are co-mingled. cDCE concentration along the western property boundary are elevated when compared to upgradient wells not influenced by the Signetics site. (Figure B-2). Mann-Kendall analysis indicates that in the last 10 years (duration used for significant statistical analysis), TCE concentrations in A zone wells located in the source area (22-S and 23-S) showed either no trend or an increasing trend, likely due to the influence of groundwater from the adjacent Signetics Site, and/or due to the fact that TCE is desorbing from soil into groundwater (Figure B-3).

TCE concentrations in downgradient wells 36-S and 37-S resulted in decreasing and no trend, respectively. Downgradient wells are elevated above the MCLs and are strongly influenced by the Signetics Site (Figure B-11).

B1 Zone

In the B1 zone, concentrations have also significantly declined since ISB startup, and breakdown products of TCE, including cDCE and vinyl chloride, are evident on the time series plots (Figure B-4). The direction of groundwater flow in the B1 zone is to the north-northeast, and therefore contaminated groundwater from the Signetics Site is predicted to influence the AMD Site (Figure B-5). Mann-Kendall analysis indicates that in the last 10 years, TCE concentrations in B1 zone wells showed either no trend[3] or a stable trend, likely due to the influence of contaminated groundwater from the adjacent Signetics Site, and/or due to the fact that TCE is sorbed onto subsurface soils and back-diffusing into groundwater (Figure B-6). TCE concentrations along the western property boundary and within the source area are elevated above the MCL. Wells 23-D and 27-D, located along the western property boundary contain elevated concentrations of TCE and are not responding to the ISB as other onsite wells (figure B-4).

B2 Zone

ISB activities are reducing off-site, down-gradient concentrations from the source area in the B2 Zone. Based on the presence of breakdown products, it appears that bioremediation is actively occurring (Figure B-7). The direction of groundwater flow in the B2 zone is to the north-northeast, and therefore contaminated groundwater from the Signetics Site is predicted to influence the AMD Site (Figure B-8). Mann-Kendall analysis indicates that in the last 10 years, TCE concentrations in various B2 zone wells showed mixed trends, either stable, increasing, or decreasing (Figure B-9). The variability and lack of a clear decreasing trend is likely due to the influence of contaminated groundwater from the adjacent Signetics Site. Though TCE concentrations remain above the MCL, levels are gradually declining at well 27-DD despite being up-gradient of the treatment area.

[3] In terms of using the statistical analysis to determine whether concentrations are increasing, decreasing or stable over time, a "No Trend" result can be considered as evidence that over a specified timeframe the concentration is neither i. increasing, ii. decreasing or iii. stable, at the relevant sampling point. A result of "No Trend" suggest that over the specified timeframe, concentrations were not stable meaning they fluctuated both up and down.

Table B-1. AMD summary data collected during the recent five-year period

	2014	2015	2016	2017	2018
Maximum Water Elevation (A Zone), feet msl	41.35	40.43	40.15	41.73	42.13
Minimum Water Elevation (A Zone), feet msl	34.87	34.29	34.37	35.06	35.46
Maximum Water Elevation (B1 Zone), feet msl	42.21	41.38	41.86	43.50	43.96
Minimum Water Elevation (B1 Zone), feet msl	34.90	34.15	34.36	35.08	35.52
Maximum Water Elevation (B2 Zone), feet msl	40.97	39.98	40.91	42.49	43.38
Minimum Water Elevation (B2 Zone), feet msl	35.34	34.57	35.01	36.36	36.57
Water Elevation at 35-DDD (B3 Zone), feet msl	39.58	37.99	39.95	41.04	42.80
Number of A-Zone Wells with VOCs > MCL	8	8	8	9	9
Number of B1-Zone Wells with VOCs > MCL	8	7	6	6	7
Number of B2-Zone Wells with VOCs > MCL	3	3	3	2	3
Maximum TCE Concentration (A Zone), µg/L	210	100	71	420	59
Maximum TCE Concentration (B1 Zone), µg/L	280	260	270	200	290
Maximum TCE Concentration (B2 Zone), µg/L	180	170	190	150	150
Maximum cDCE Concentration (A Zone), µg/L	180	220	570	350	310
Maximum cDCE Concentration (B1 Zone), µg/L	23	100	26	3.5	130
Maximum cDCE Concentration (B2 Zone), µg/L	7.1	10	9.9	27	9.8
Maximum VC Concentration (A Zone), µg/L	62	66	88	73	29
Maximum VC Concentration (B1 Zone), µg/L	84	250	68	15	4.3
Maximum VC Concentration (B2 Zone), µg/L	0.8	1.7	7.3	1.4	1.3

Notes:

1. This table presents only data for wells in the annual monitoring program. In 2018, B1-Zone well 16-D was replaced with DW-7 in the monitoring program with EPA approval.

Abbreviations:

µg/L = micrograms per liter
cDCE = cis-1,2-dichloroethene
feet msl = feet above mean sea level
ISB = in situ bioremediation
MCL = Maximum Contaminant Level
TCE = trichloroethene
VC = vinyl chloride
VOCs = volatile organic compounds

Table B-2. AMD contaminant concentrations at the beginning and most current annual data.

Concentrations reported in micrograms per liter (µg/L)

Well ID	TCE		cDCE		Vinyl Chloride		Mole Fraction Ethene & Ethane[1]
	Start of ISB (2005)	Most Recent (2018)	Start of ISB (2005)	Most Recent (2018)	Start of ISB (2005)	Most Recent (2018)	2018
A Zone							
16-S	**6.1**[2]	<0.50[3] (-100%)[4]	**29**	**3.0** (-90%)	**37**	**29** (-22%)	28%
23-S	**37**	**38** (+3%)	**84**	**42** (-50%)	**31**	**0.60** (-98%)	3.0%
28-MW	**10**	<0.50 (-100%)	**26**	**0.71** (-97%)	**28**	**14** (-50%)	60%
DW-2	**3.0**[5]	<0.50[6] (-100%)	**110**	<0.50 (-100%)	<0.7	<0.50 (0%)	100%
X2A	**200**	<5.0 (-100%)	**230**	**49** (-79%)	**62**	**980** (+1,481%)	11%
B1 Zone							
16-D	**740**	<0.50[7] (-100%)	**970**	**2.1** (-100%)	**45**	**7.7** (-83%)	98%
23-D	**230**	**290** (+26%)	**390**	**3.7** (-99%)	**56**	<2.5 (-100%)	0.057%
PMW-2-1	**82**	<50 (-100%)	**6,700**	**4,800** (-28%)	**2,300**	**430** (-81%)	4.9%
DW-1	**440**	<0.50[8] (-100%)	**3,700**	**0.78** (-100%)	**32**	**3.0** (-91%)	96%
DW-7	**300**	**69** (-77%)	**100**	**130** (+30%)	**4.6**	**4.3** (-7%)	0.26%
X1B	**360**	<10 (-100%)	**1,600**	**300** (-81%)	**120**	**140** (+17%)	3.5%
X2B1	**420**	**150** (-64%)	**420**	**110** (-74%)	**41**	**7.8** (-81%)	5.4%
B2 Zone							
PMW-2-3	**290**	**270** (-7%)	**440**	**75** (-83%)	**24**	**11** (-54%)	1.3%

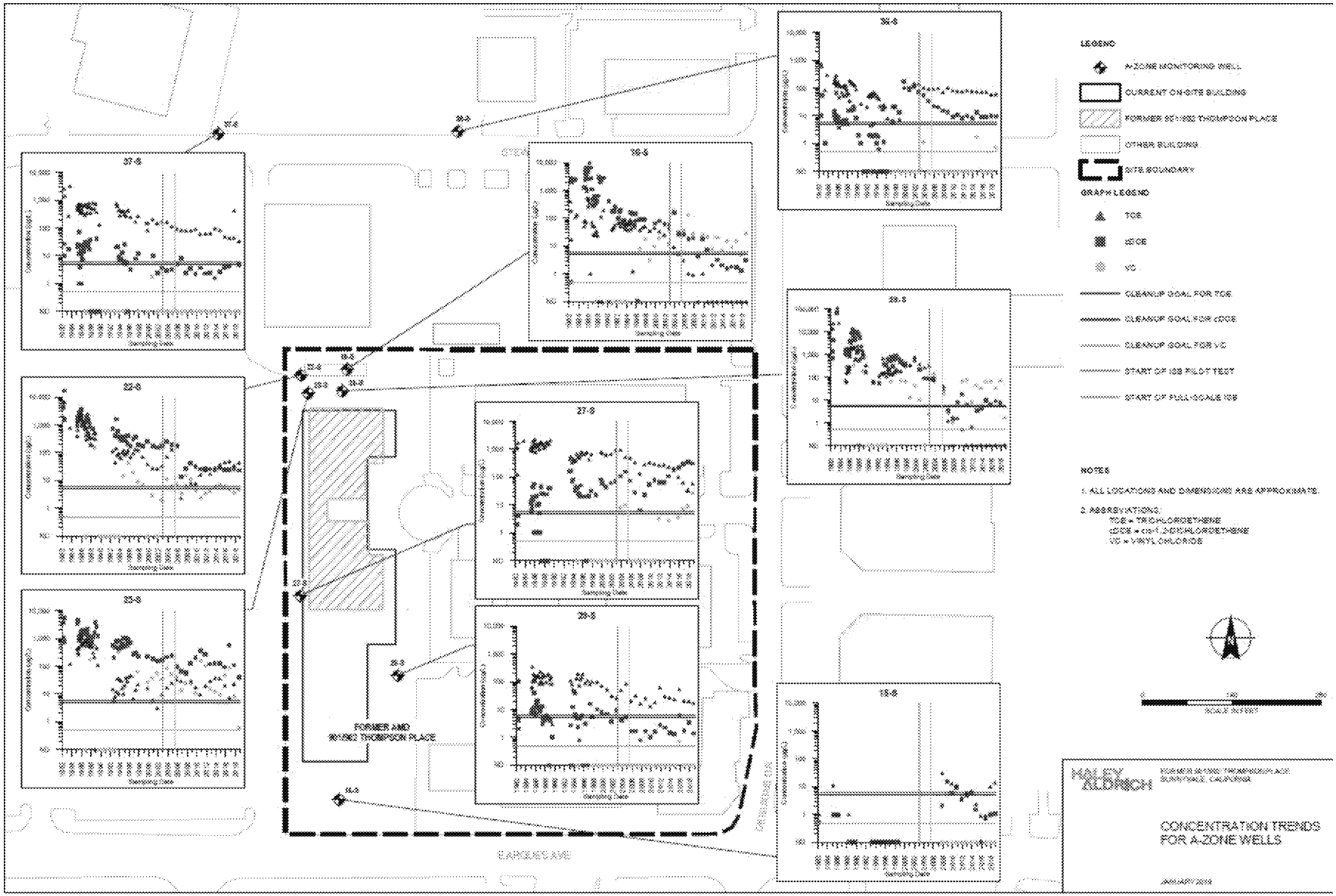


Figure B-1. Concentration trends for A-zone wells for TCE, cDCE and vinyl chloride

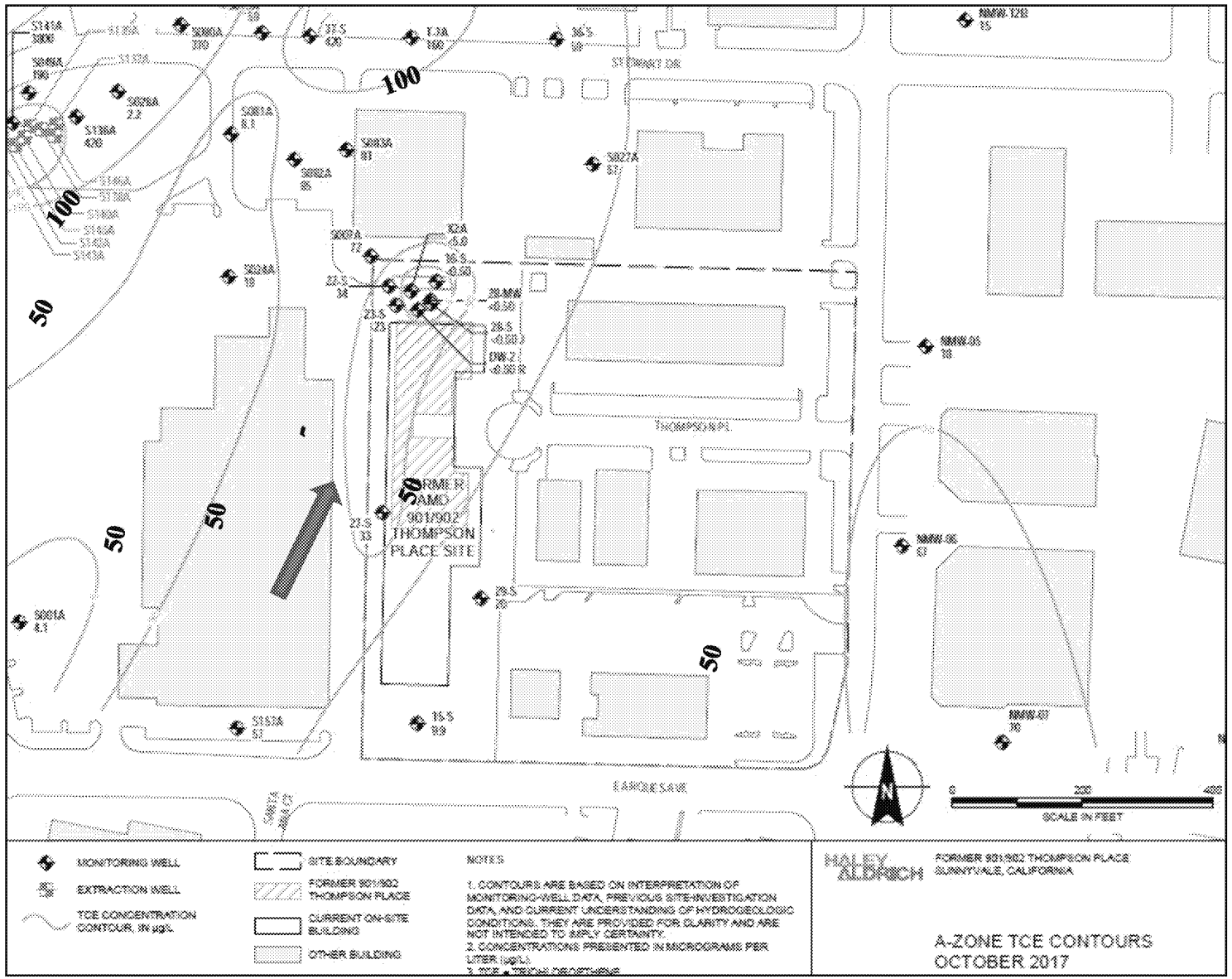


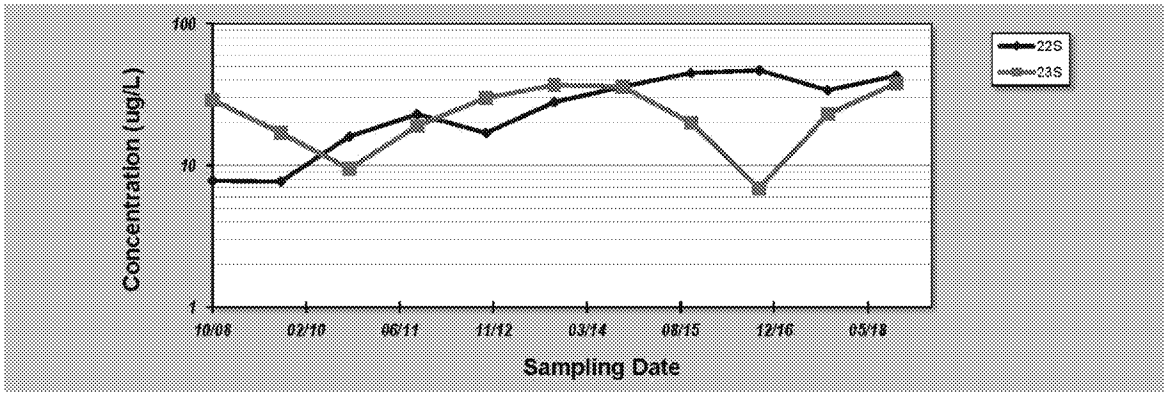
Figure B-2. Groundwater Flow in the AMD A Zone is North-Northeast

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date: 9-Feb-19
Facility Name: AMD 901/902
Conducted By: K.Addis

Job ID: Source Area A Zone
Constituent: TCE
Concentration Units: ug/L

Sampling Point ID:	22S	23S					
Sampling Event	Sampling Date	TCE CONCENTRATION (ug/L)						
1	Oct-08	7.8	29					
2	Oct-09	7.7	17					
3	Oct-10	16	9.5					
4	Oct-11	23	19					
5	Oct-12	17	30					
6	Oct-13	28	37					
7	Oct-14	36	36					
8	Oct-15	45	20					
9	Oct-16	47	6.9					
10	Oct-17	34	23					
11	Oct-18	43	38					
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.32	0.45					
Mann-Kendall Statistic (S):		47	13					
Confidence Factor:		100.0%	82.1%					
Concentration Trend:		Increasing	No Trend					



Notes:

1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales; *Ground Water* , 41(3):355-367, 2003.

Figure B-3. Mann-Kendall Statistics for TCE in A Zone Wells in the AMD Source Area.

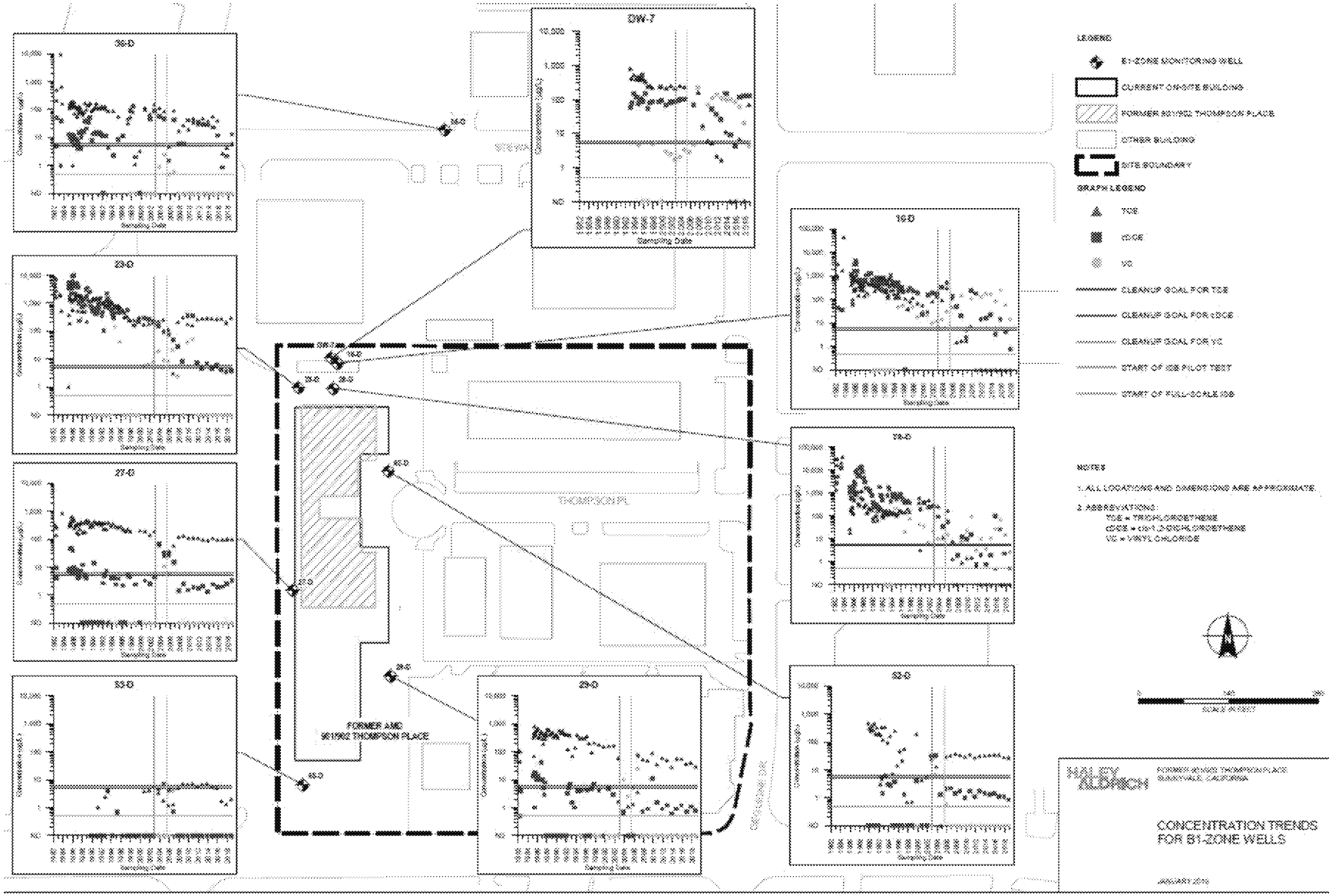


Figure B-4. Concentration trends for B1-zone wells for TCE, cDCE and vinyl chloride

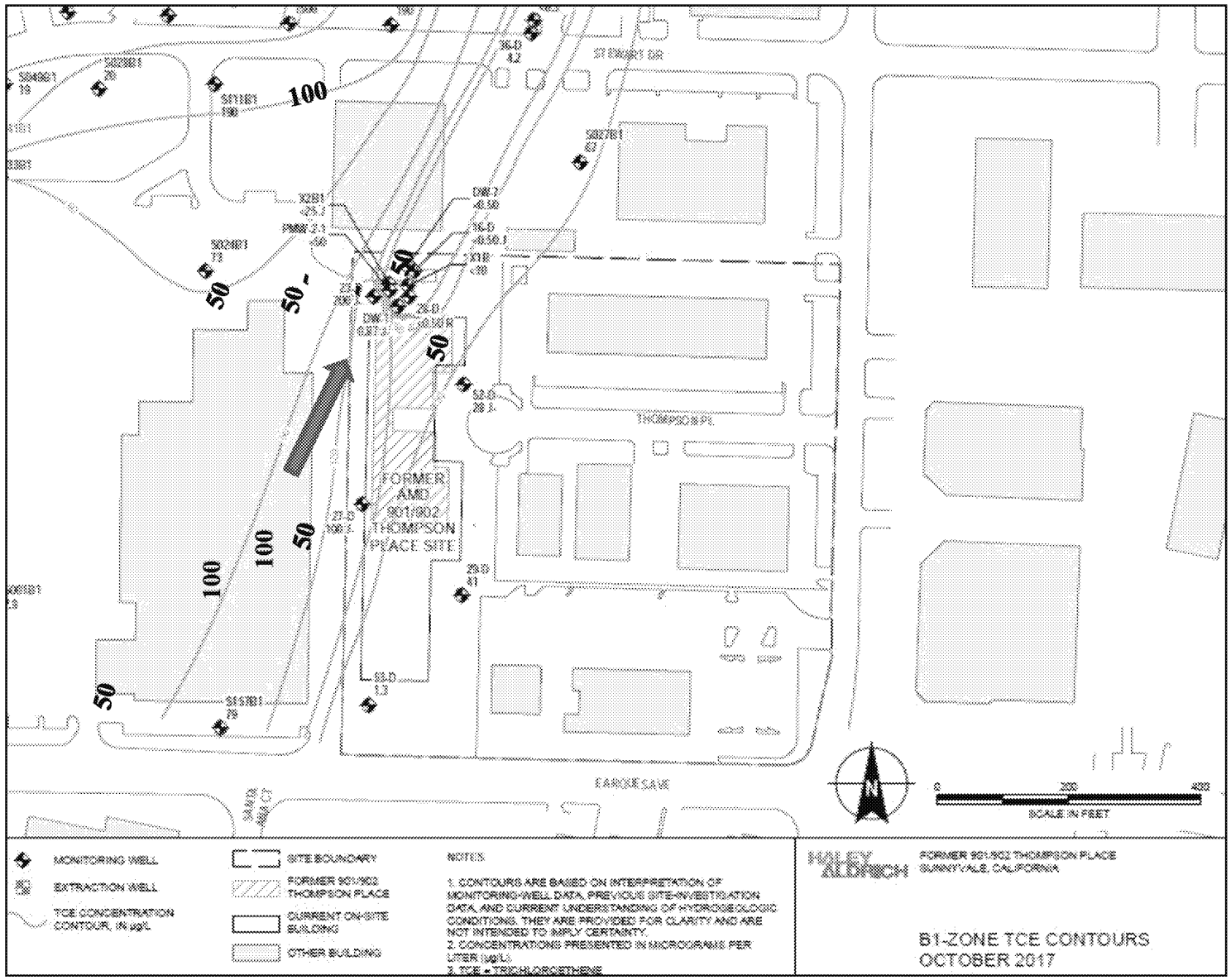
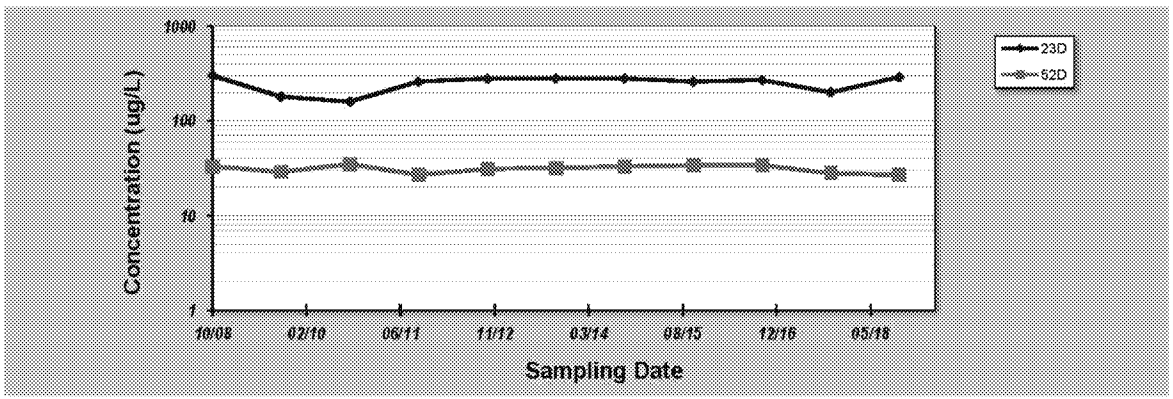


Figure B-5. Groundwater Flow in the AMD B1 Zone is North-Northeast

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	9-Feb-19	Job ID:	Source Area B1 Zone
Facility Name:	AMD 901/902	Constituent:	TCE
Conducted By:	K.Addis	Concentration Units:	ug/L

Sampling Point ID:	23D	52D					
Sampling Event	Sampling Date	TCE CONCENTRATION (ug/L)						
1	Oct-08	300	33					
2	Oct-09	180	29					
3	Oct-10	160	35					
4	Oct-11	260	27					
5	Oct-12	280	31					
6	Oct-13	280	32					
7	Oct-14	280	33					
8	Oct-15	260	34					
9	Oct-16	270	34					
10	Oct-17	200	28					
11	Oct-18	290	27					
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.19	0.09					
Mann-Kendall Statistic (S):		-4	-4					
Confidence Factor:		61.9%	69.0%					
Concentration Trend:		No Trend	Stable					



Notes:

1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

Figure B-6. Mann-Kendall Statistics for TCE in B1 Zone Wells in the AMD Source Area.

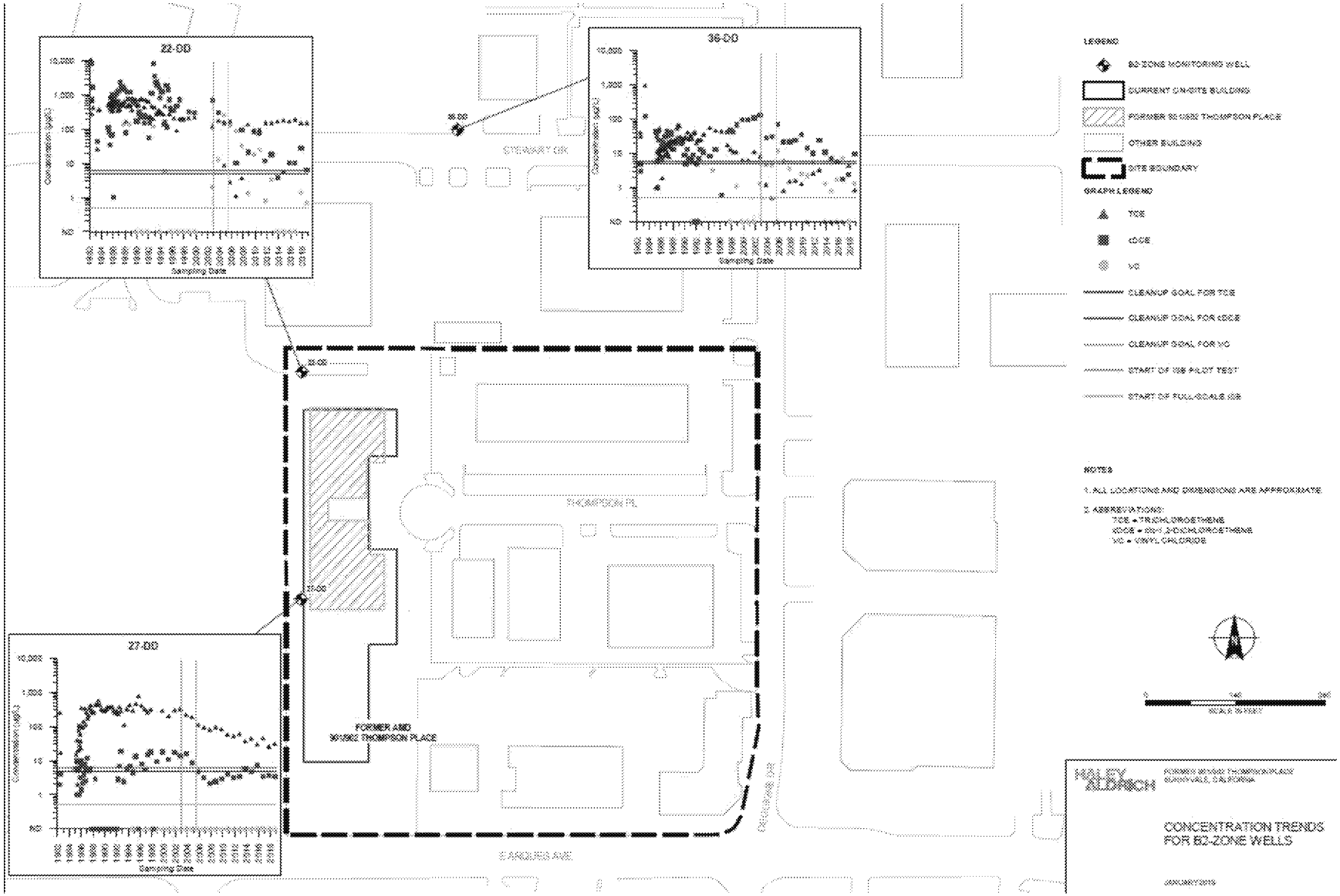


Figure B-7. Concentration trends for B2-zone wells for TCE, cDCE and vinyl chloride

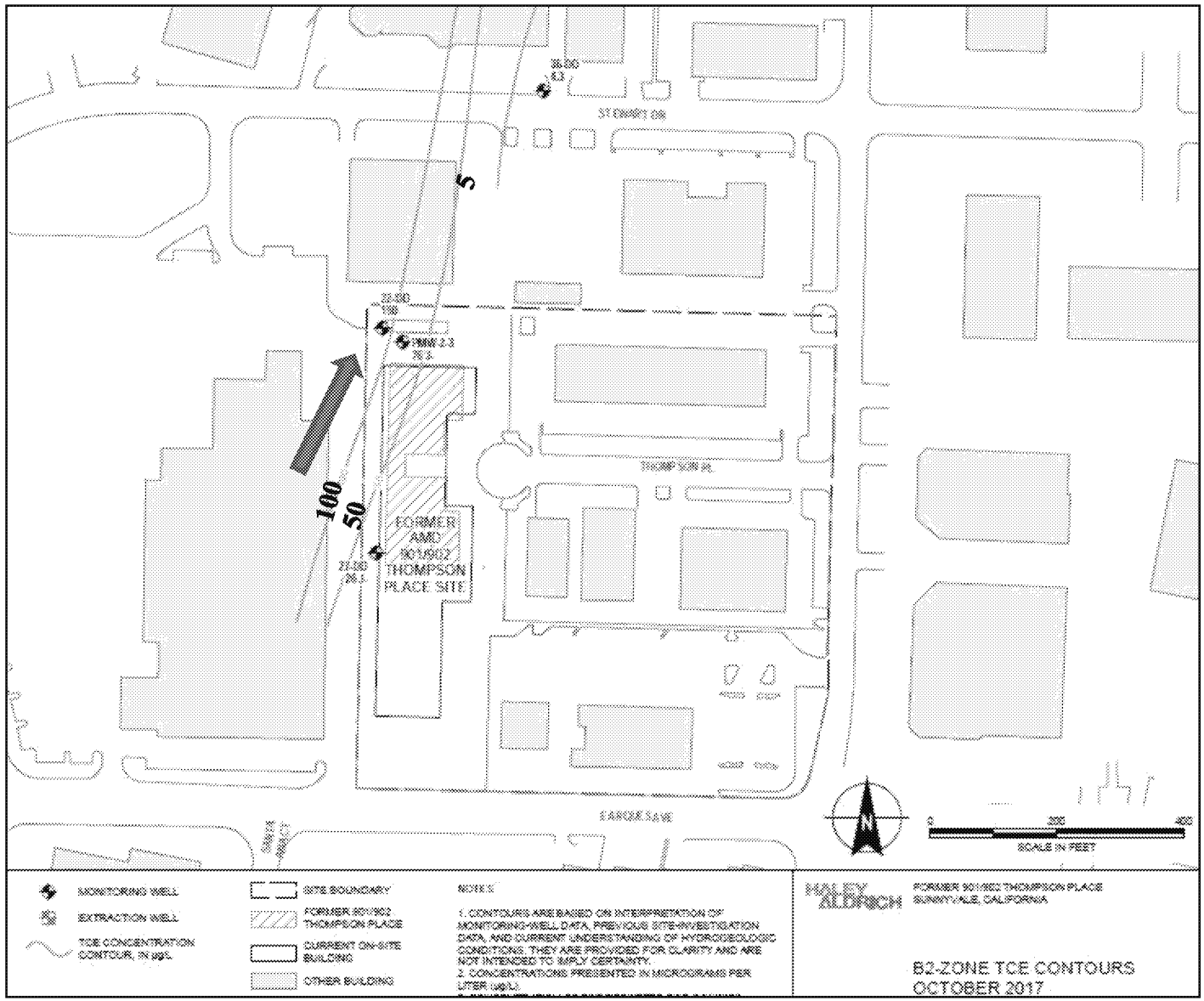
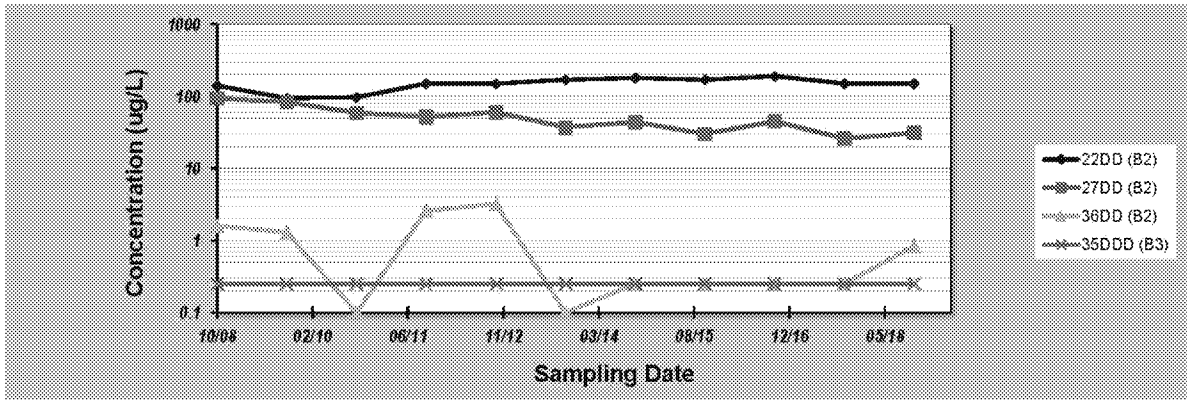


Figure B-8. Groundwater Flow in the AMD B2 Zone is North-Northeast

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	9-Feb-19	Job ID:	Source Area B2 and B3 Zones
Facility Name:	AMD 901/902	Constituent:	TCE
Conducted By:	K.Addis	Concentration Units:	ug/L

Sampling Point ID:	22DD (B2)	27DD (B2)	36DD (B2)	35DDD (B3)			
Sampling Event	Sampling Date	TCE CONCENTRATION (ug/L)						
1	Oct-08	140	94	1.6	0.25			
2	Oct-09	94	83	1.3	0.25			
3	Oct-10	97	59	0.1	0.25			
4	Oct-11	150	52	2.6	0.25			
5	Oct-12	150	60	3.2	0.25			
6	Oct-13	170	37	0.1	0.25			
7	Oct-14	180	44	0.25	0.25			
8	Oct-15	170	30	0.25	0.25			
9	Oct-16	190	45	0.25	0.25			
10	Oct-17	150	26	0.25	0.25			
11	Oct-18	150	31	0.84	0.25			
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.20	0.43	1.11	0.00			
Mann-Kendall Statistic (S):		26	-48	-8	0			
Confidence Factor:		97.2%	99.9%	64.9%	45.1%			
Concentration Trend:		Increasing	Decreasing	No Trend	Stable			



Notes:

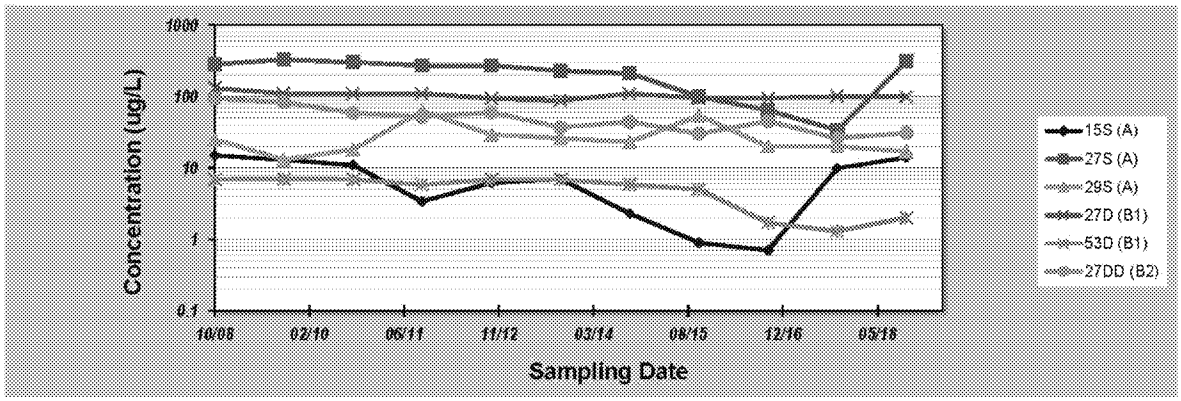
1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (*S*>0) or decreasing (*S*<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

Figure B-9. Mann-Kendall Statistics for TCE in B2 and B3 Zone Wells in the AMD Source Area

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	9-Feb-19	Job ID:	Upgradient wells
Facility Name:	AMD 901/902	Constituent:	TCE
Conducted By:	K.Addis	Concentration Units:	ug/L

Sampling Point ID:		15S (A)	27S (A)	29S (A)	27D (B1)	53D (B1)	27DD (B2)
Sampling Event	Sampling Date	TCE CONCENTRATION (ug/L)					
1	Oct-08	15	280	25	130	6.9	94
2	Oct-09	13	330	13	110	7	83
3	Oct-10	11	300	18	110	6.9	59
4	Oct-11	3.4	270	62	110	5.8	52
5	Oct-12	6.2	270	29	94	6.9	60
6	Oct-13	7	230	26	88	6.9	37
7	Oct-14	2.3	210	23	110	5.8	44
8	Oct-15	0.9	100	54	95	5	30
9	Oct-16	0.7	64	20	95	1.7	45
10	Oct-17	9.9	34	20	100	1.3	26
11	Oct-18	14	310	17	99	2	31
12							
13							
14							
15							
16							
17							
18							
19							
20							
Coefficient of Variation:		0.78	0.44	0.56	0.11	0.45	0.43
Mann-Kendall Statistic (S):		-19	-37	-9	-30	-38	-38
Confidence Factor:		91.5%	99.4%	70.1%	92.9%	99.5%	99.5%
Concentration Trend:		Prob. Decreasing	Decreasing	Stable	Prob. Decreasing	Decreasing	Decreasing



Notes:

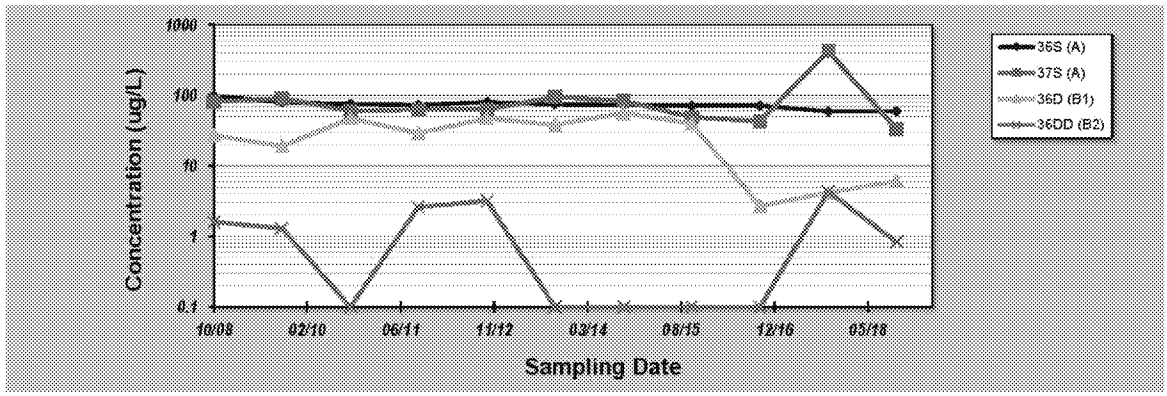
1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (*S*>0) or decreasing (*S*<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

Figure B-10. Mann-Kendall Statistics for TCE in AMD Upgradient Wells

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	9-Feb-19	Job ID:	AMD 901/902
Facility Name:	AMD 901/902	Constituent:	TCE
Conducted By:	K.Addis	Concentration Units:	ug/L

Sampling Point ID:	36S (A)	37S (A)	36D (B1)	36DD (B2)			
Sampling Event	Sampling Date	TCE CONCENTRATION (ug/L)						
1	Oct-08	98	81	27	1.6			
2	Oct-09	80	91	19	1.3			
3	Oct-10	75	60	47	0.1			
4	Oct-11	73	63	29	2.6			
5	Oct-12	80	63	47	3.2			
6	Oct-13	74	95	38	0.1			
7	Oct-14	73	83	56	0.1			
8	Oct-15	71	49	40	0.1	fgvvv		
9	Oct-16	71	43	2.7	0.1			
10	Oct-17	59	420	4.2	4.3			
11	Oct-18	59	33	6.1	0.84			
12								
13								
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.14	1.10	0.65	1.13			
Mann-Kendall Statistic (S):		-18	-4	-6	-3			
Confidence Factor:		>95.5%	76.9%	76.9%	56.6%			
Concentration Trend:		Decreasing	No Trend	Stable	No Trend			



Notes:

1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

Figure B-11. Mann-Kendall Statistics for TCE in AMD Downgradient Wells

TRW Microwave Site

USACE evaluated the effectiveness of the remedial actions for soil and groundwater during the review period to assess if the RAOs are being met, in particular controlling migration and restoration of the aquifer to drinking water. The four chemical contaminants of interest at the TRW Site are TCE, cDCE, vinyl chloride and Freon 113 (from Signetics Site)

The TRW Site is located directly down-gradient of the AMD Site and the eastern portion of the Signetics Site (southern boundary). The TRW Site is also upgradient from the AMD 915 DeGuigne Drive Site (AMD 915 Site). The RPs conducted several subsurface investigations including 1) excavation of contaminated soils and 2) subsurface investigation to improve the understanding of the units transporting the majority of the mass, in an effort to improve the effectiveness of the EAB program.

Soil Excavation

TRW's consultant removed a total of 590 tons of VOC impacted soil from the source area during 2014 (Figure B-12). Confirmation samples collected confirmed the remediation to a depth ranging 25 to 30 feet below ground surface. Twelve of the 39 locations identified in contained concentrations of TCE and/or cis-1,2-DCE above the cleanup levels. Some areas exceeding the cleanup level were not excavated removed due to 1) depth exceeding 25 feet, 2) below groundwater and not feasible to excavate, or 3) in close proximity to the building/building footings. These locations with soil remaining in place that continue to exceed the cleanup level are circled on Figure B-12.

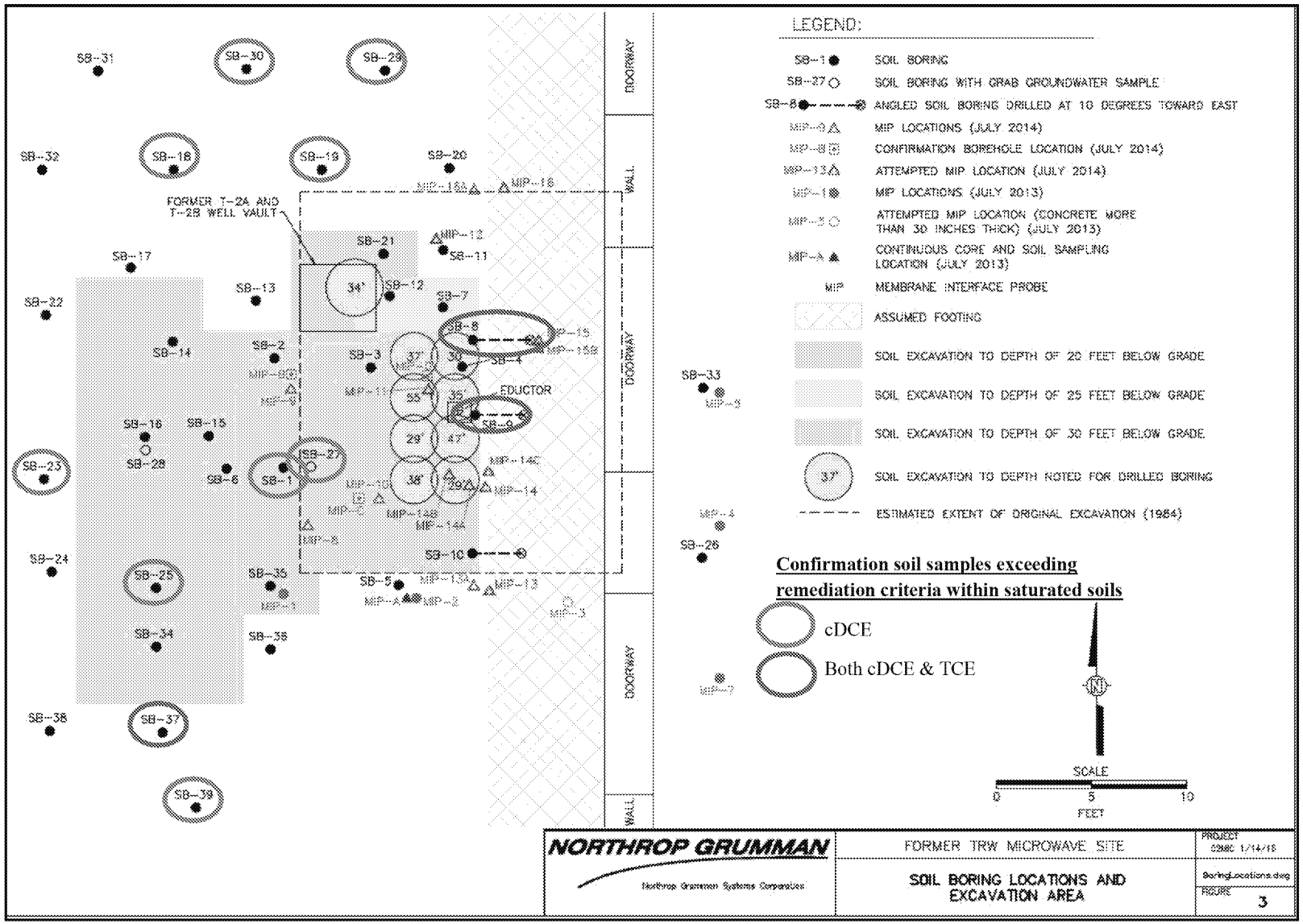


Figure B-12. TRW 2014 Soil Excavation and Boring Locations

Groundwater

The groundwater monitoring program at the TRW Site consists of two components: 1) evaluation of the non-pumping condition; and 2) semi-annual groundwater monitoring to assess the Enhanced Anaerobic Bioremediation (EAB) program. The four chemical contaminants of interest at the TRW Site are TCE, cDCE, and vinyl chloride, all of which are currently exceeding current ROD cleanup levels. Freon 113 is present at deeper level within the aquifer and is utilized as a tracer for co-mingling plumes from the Signetics Site.

EPA assessed contaminant migration by reviewing a combination of factors, including groundwater contours, contaminant trends, vertical groundwater gradients and contaminant trends in underlying aquifer zones. Wells were selected for Mann-Kendall statistical trend analysis that were in the central portion of the contaminated areas and were either upgradient, directly downgradient of the source area or at the down- or cross-gradient property boundary with the Signetics Site. Each aquifer zone is evaluated separately then and overall assessment will be discussed.

The groundwater flow directions for the A, B1, and B2 zones at the TRW Site range from the north to the north-northeast. However, the hydrostratigraphic units within the aquifer zone can also modify the flow pathway on a local scale (Figure B-13) as discussed in Section 3.2. The detailed subsurface mapping assists in identifying specific area transporting the majority of VOC through these pathways and identifies units where offsite migration is occurring, Recent data is presented in Table B-3. In addition, the operation of the groundwater extraction and treatment systems (GWETSs) at Signetics and AMD 915 may affect the flow direction and gradients when operational.

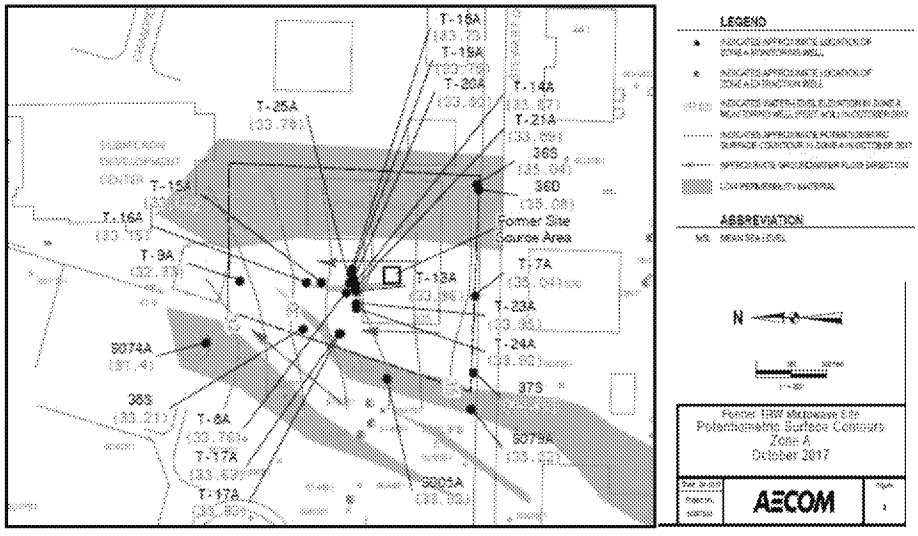


Figure B-13. TRW A Aquifer Zone hydrostratigraphic units Showing Channelized Flow Patterns and Groundwater Contours (note figure orientation)

In A Zone wells, TCE concentrations have mostly remained stable during the review period with the exception of T-13A and T-2A. Slight decreases in TCE concentrations are observed following the soil removal action and decommissioning of Well T-2A in 2014 (Figure B-14). It is also important to note that the location with the greatest concentration is at the upgradient well T-7A (Figure B-15). Wells within the TRW source area have moderately responded to EAB treatment and slight improvements are observed following excavation of contaminated soils. This suggests that the saturated soil concentrations are not the controlling factor in the status of the TCE plume within the A Zone of the aquifer. Mann-Kendall analysis indicates TCE concentrations are either stable or show no trend despite the Northrop Grumman's efforts with the EAB program (Figure B-16) and remain elevated above the ROD cleanup levels.

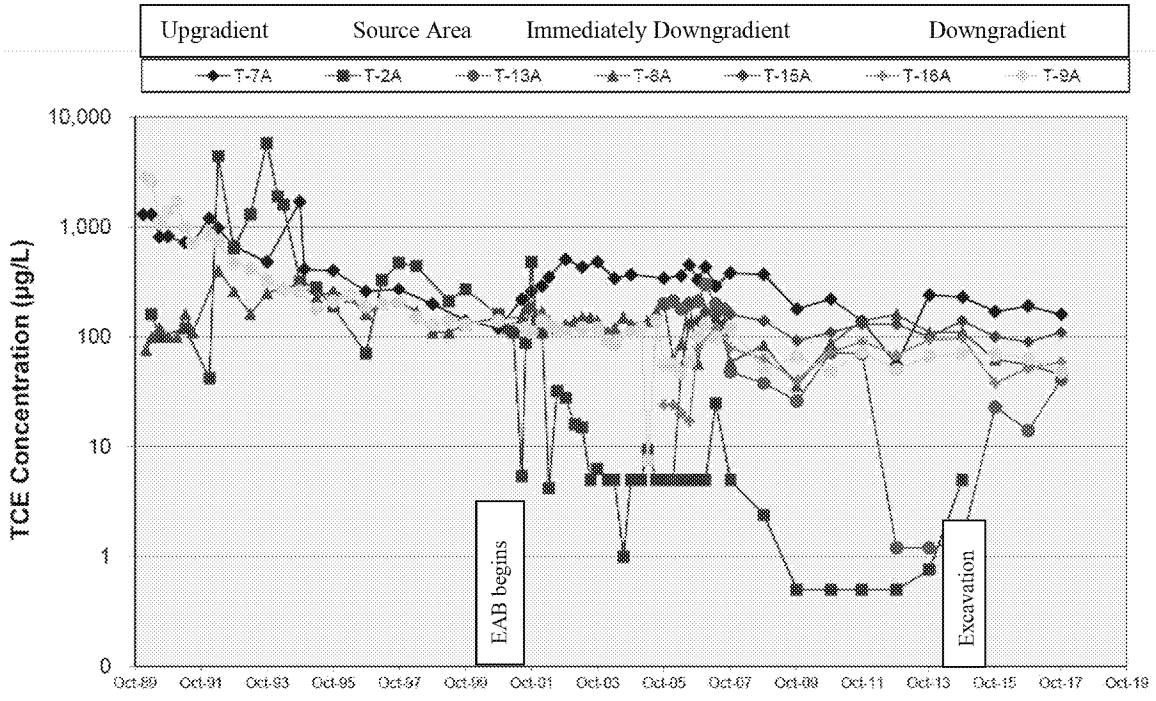


Figure B-14. Time Series plots for TCE in the A level of the TRW site, with excavation in the source area occurring in 2014. Relative position of wells is identified along the top row from upgradient (left) to downgradient (right) (Source: AECOM, 2017).

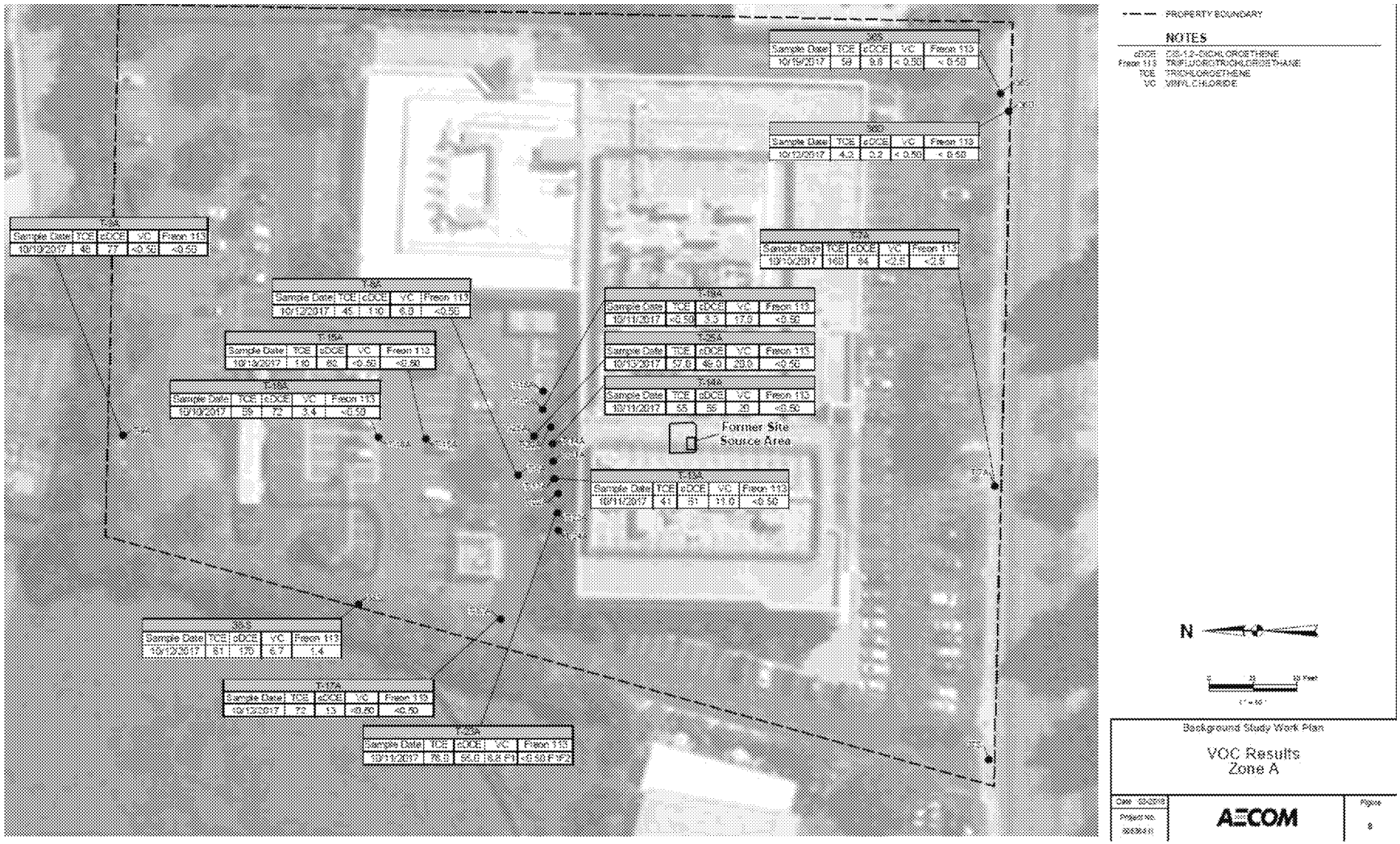
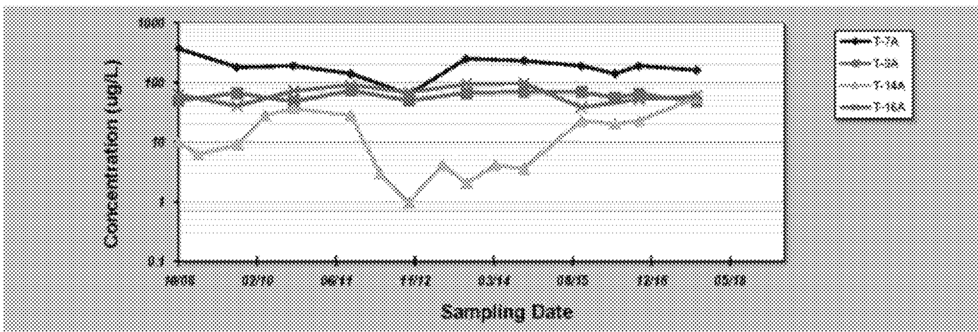


Figure B-15. 2017 Chemical Contaminant Results for TRW Zone A within the Shallow Aquifer

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	10-Feb-18	Job ID:	A Zone
Facility Name:	TRW	Constituent:	TCE
Conducted By:	K.Addis	Concentration Units:	ug/L

Sampling Event	Sampling Date	T-7A	T-9A	T-14A	T-16A			
		TCE CONCENTRATION (ug/L)						
1	Oct-08	370	50	10	63			
2	Feb-09			6.2				
3	Oct-09	180	68	9	40			
4	Apr-10			28				
5	Oct-10	190	48	36	72			
6	Oct-11	140	73	28	91			
7	Apr-12			3				
8	Oct-12	63	50	0.96	68			
9	May-13			4.2				
10	Oct-13	250	87	2	94			
11	Apr-14			4.1				
12	May-14							
13	Oct-14	230	70	3.6	87			
14	Oct-15	190	69	23	38			
15	May-16	140	58	20				
16	Oct-16	190	64	23	52			
17	Oct-17	160	48	55	59			
18								
19								
20								
Coefficient of Variation:		0.40	0.16	0.86	0.32			
Mann-Kendall Statistic (S):		-11	4	2	1			
Confidence Factor:		77.7%	58.0%	62.2%	50.0%			
Concentration Trend:		Stable	Stable	No Trend	No Trend			



Notes:

1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

Figure B-16. Mann-Kendall Statistics for TCE in A Zone Wells in the TRW Site

In B1 Zone wells, TCE concentrations have mostly remained stable and elevated above the remediation level during the review period with the exception of T-4B and T-8B, which had a significant decrease in TCE concentrations following the soil removal action in 2014 (Figure B-17). B1 Zone wells resulted in 12 out of 14 wells containing concentrations of one or more constituent exceeding cleanup levels (Figure B-18). Mann-Kendall analysis indicates concentrations are either stable or show no trend in upgradient or cross gradient wells (T-7B and T-17B). Trends for wells directly downgradient from the source area (T-8B and T-10B) are decreasing and probably decreasing, respectively, suggesting the EAB program is effectively degrading contaminants (Figure B-19).

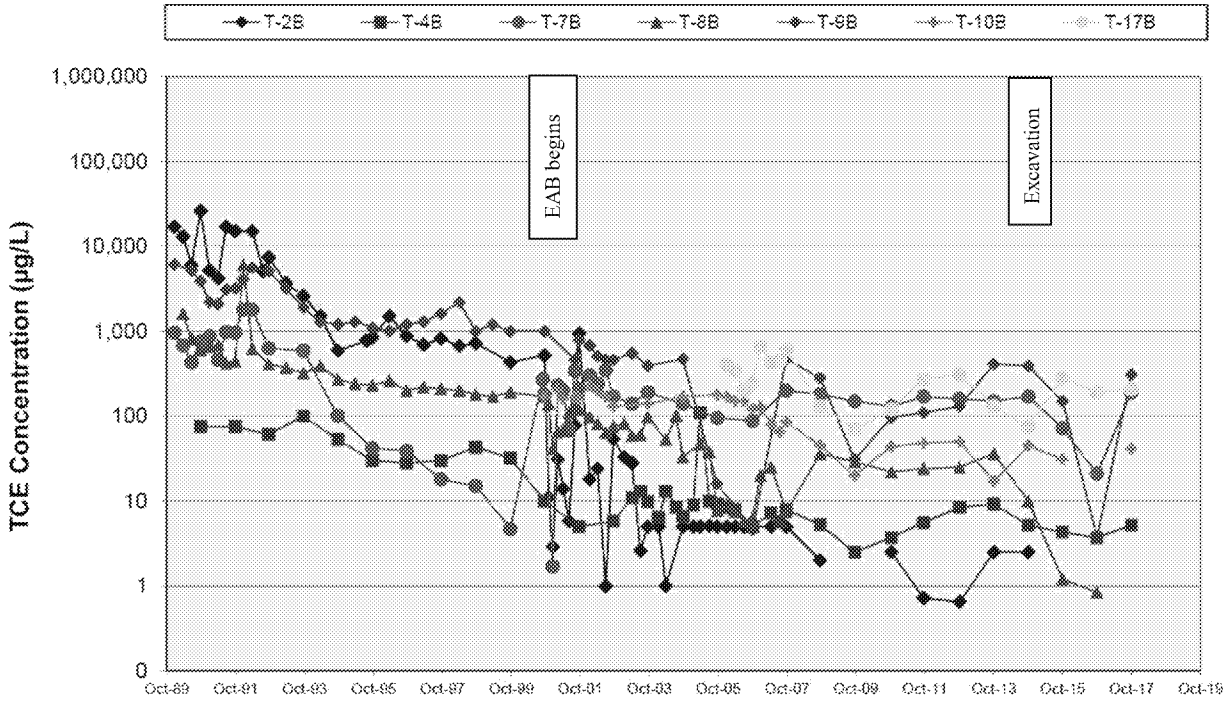


Figure B-17. Time Series plots for TCE in the B1 level of the TRW site, with EAB program beginning in 2000 and excavation in the source area occurring in 2014. (Source: AECOM, 2017).

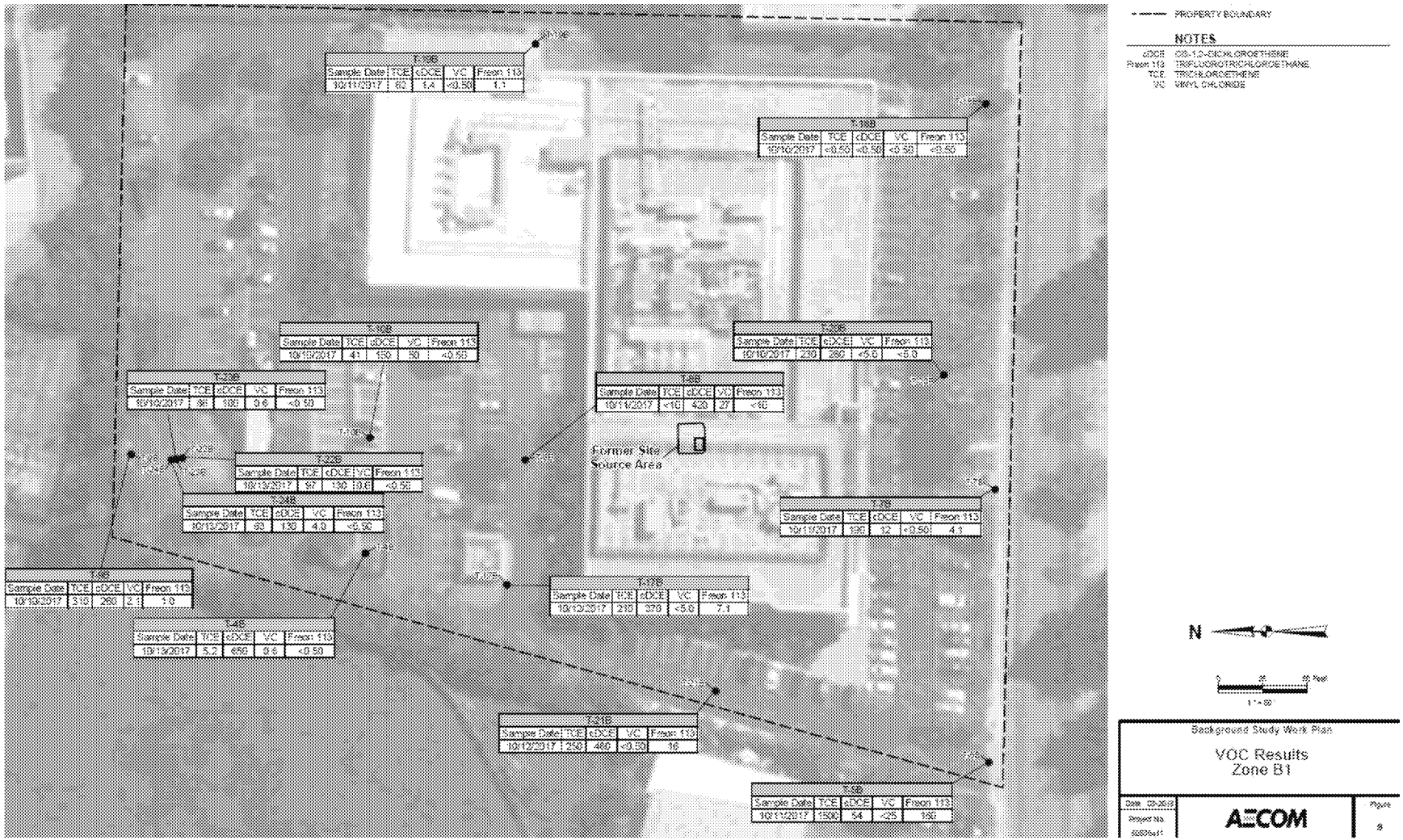
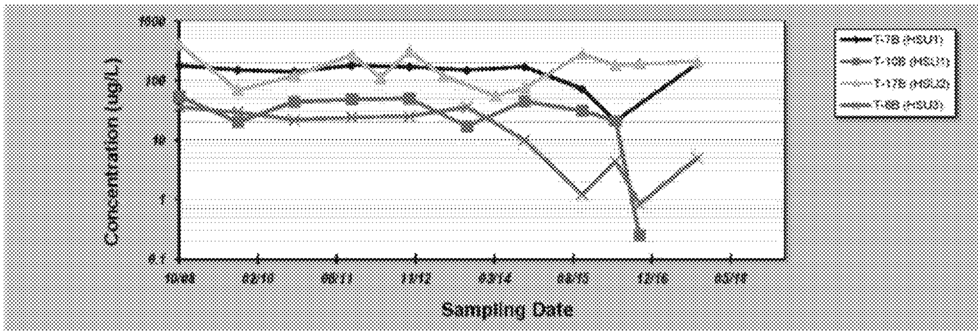


Figure B-18. 2017 chemical contaminant Results for TRW Zone B1 within the Shallow Aquifer

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	10-Feb-19	Job ID:	B1 Zone
Facility Name:	TRW	Constituent:	TCE
Conducted By:	K.Addis	Concentration Units:	ug/L

Sampling Event	Sampling Date	T-7B (HSU1)	T-10B (HSU1)	T-17B (HSU3)	T-8B (HSU3)			
		TCE CONCENTRATION (ug/L)						
1	Oct-08	180	54	400	36			
2	Feb-09							
3	Oct-09	150	20	69	29			
4	Apr-10							
5	Oct-10	140	44	120	22			
6	Oct-11	180	48	270	24			
7	Apr-12			110				
8	Oct-12	170	50	310	25			
9	May-13			120				
10	Oct-13	150	17		36			
11	Apr-14			55				
12	May-14							
13	Oct-14	170	45	75	19			
14	Oct-15	73	31	280	1.2			
15	May-16	21	21	180	4.4			
16	Oct-16		0.29	190	0.84			
17	Oct-17	190		210	5			
18								
19								
20								
Coefficient of Variation:		0.38	0.54	0.59	0.75			
Mann-Kendall Statistic (S):		-8	-18	9	-37			
Confidence Factor:		72.9%	94.6%	64.8%	99.3%			
Concentration Trend:		Stable	Prob. Decreasing	No Trend	Decreasing			



Notes:

1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water*, 41(3):355-367, 2003.

Figure B-19 Mann-Kendall Statistics for TCE in B1 Zone Wells in the TRW Site

In B2 Zone wells, TCE concentrations have mostly remained stable and elevated above the cleanup level during the review period (Figures B-20 & B-21). Mann-Kendall analysis indicates concentrations are either stable or show no trend in upgradient or cross gradient wells (T-7B and T-17B). Trends for wells directly downgradient from the source area (T-8B and T-10B) are decreasing and probably decreasing, respectively (Figure B-22). This suggest that the EAB treatment is effective at reducing contaminants however migration from offsite sources are hindering remedial efforts at the site.

TRW's consultant used isotope testing to demonstrate the EAB pilot test is effective in treating source area contamination. The ^{13}C isotope becomes enriched compared to the ^{12}C isotope as the contaminants degrade from the EAB treatment. In the A zone, the ^{13}C isotope becomes more enriched as it moves from up-gradient wells to source area wells, suggesting effective EAB treatment. As the contaminants move from the source area toward down- and cross-gradient wells, the ^{13}C isotope is less enriched suggesting an influx of mass not originating from the TRW source area. This is observed along the northern and western property boundary. In addition. these areas also observed elevated concentrations of Freon 113, indicating an offsite source.

In summary, TRW has progressed towards meeting the RAOs of containment, however efforts are impacted by offsite migration of VOC from the Signetics site. The improvements at TRW are observed mostly in the source area where the excavation and the EAB treatments are administered.

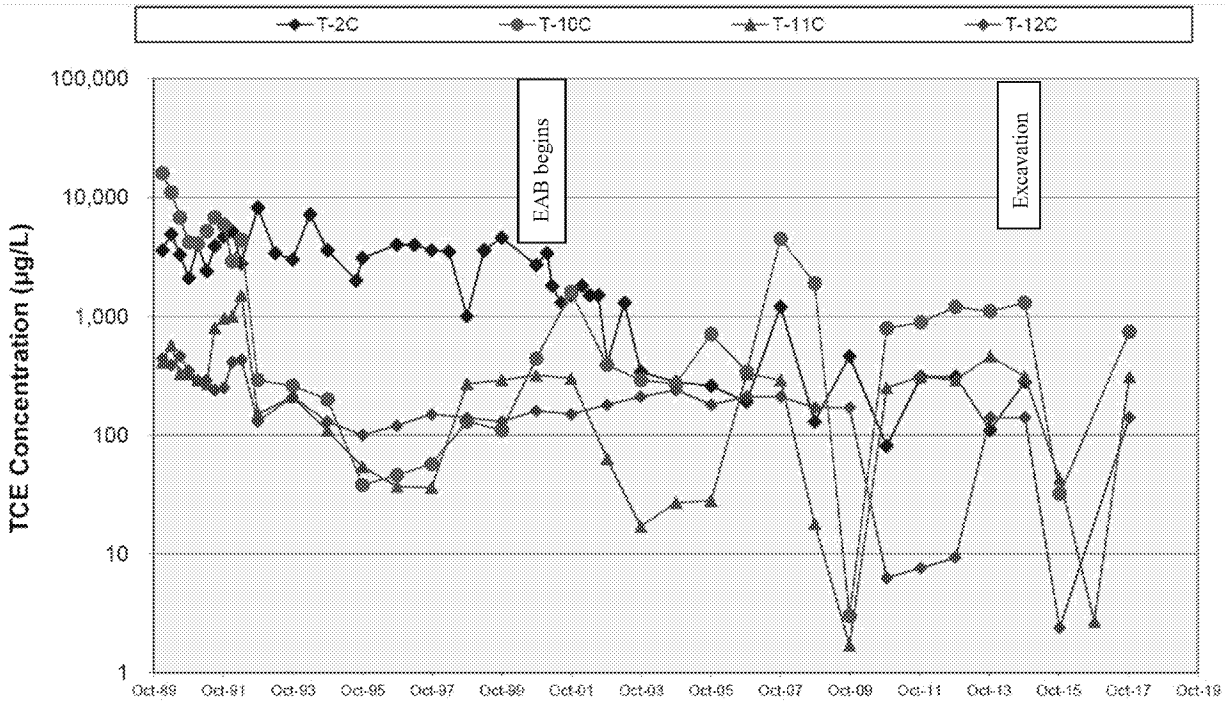


Figure B-20. Time Series plots for TCE in the B2 level of the TRW site, with EAB program beginning in 2000 and excavation in the source area occurring in 2014. (Source: AECOM, 2017).

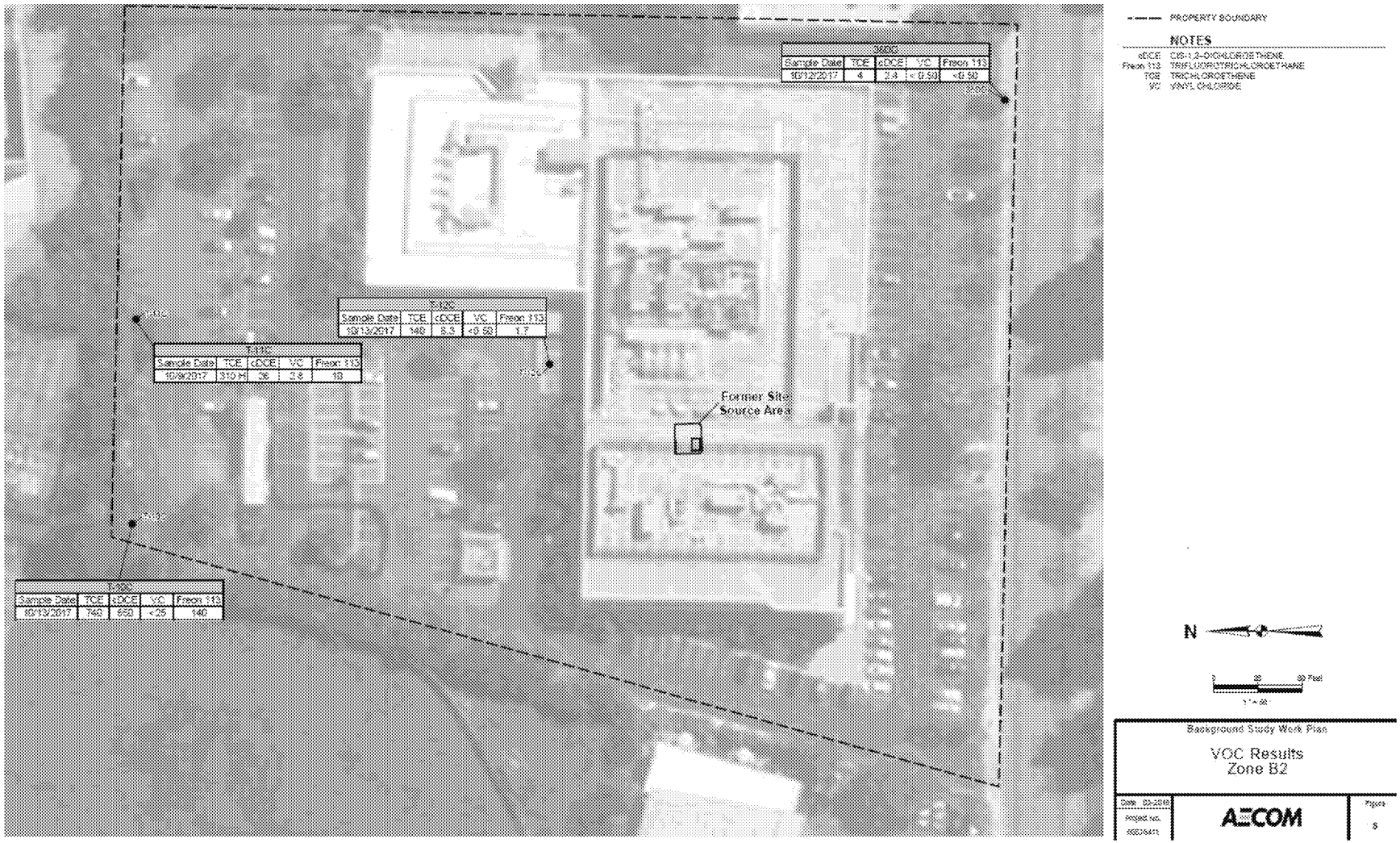


Figure B-21. 2017 chemical contaminant Results for TRW Zone B2 within the Shallow Aquifer

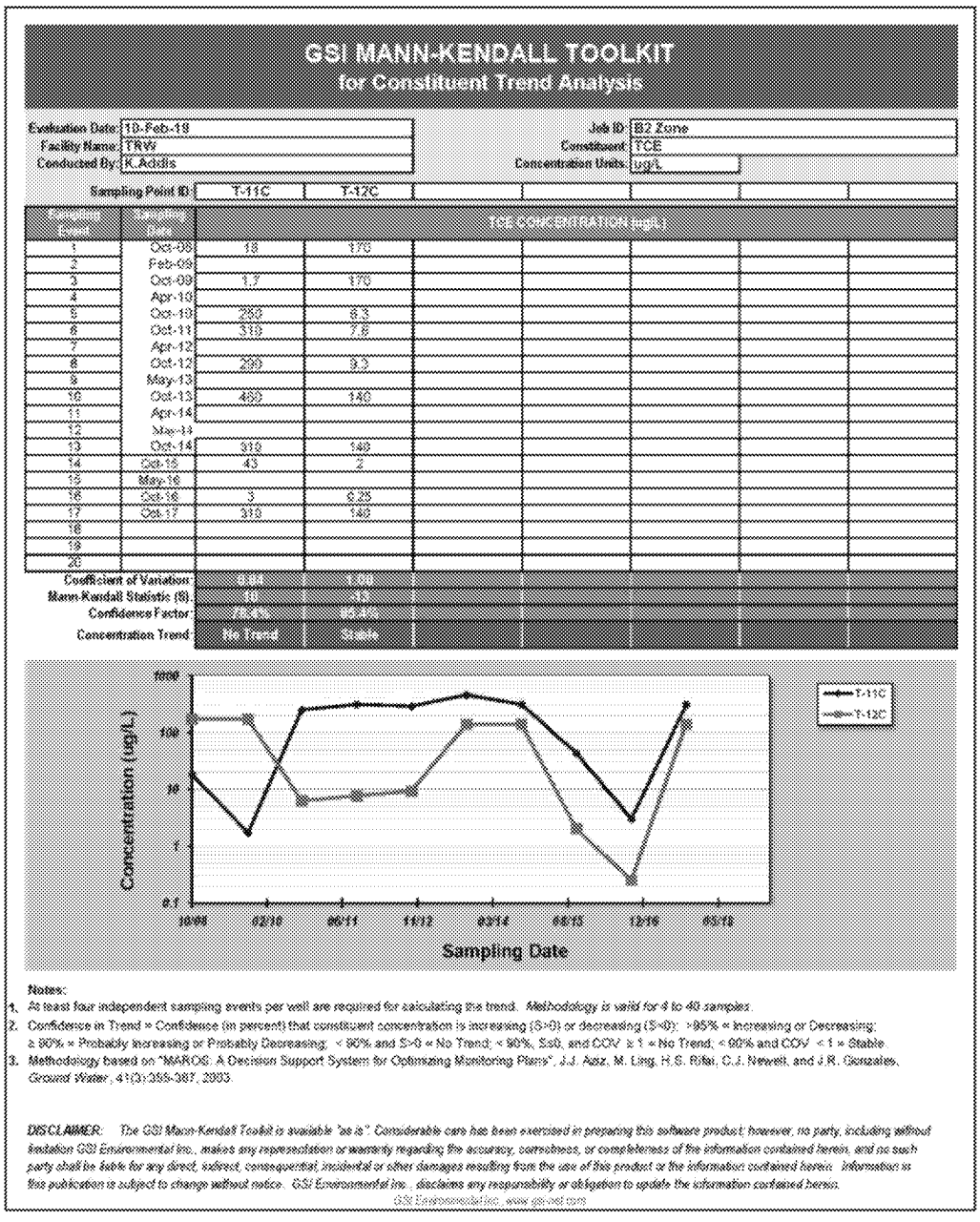


Figure B-22. Mann-Kendall Statistics for TCE in B2 Zone Wells in the TRW Site

Table B-3. Recent TRW contaminant concentrations in groundwater (2017).

Well	Zone	Sample Name	Sample Date	PCE (µg/L)	TCE (µg/L)	cDCE (µg/L)	tDCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	Freon 113 (µg/L)	1,2-DCB (µg/L)	1,4-DCB (µg/L)	CBN (µg/L)
T-1A	A	Destroyed													
T-2A	A	Destroyed													
T-3A	A	Destroyed													
T-7A	A	J6039-T7A-101017-1	10/10/2017	<2.5	160	82	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
T-7A Dup	A	J6039-T7A-101017-2	10/10/2017	<2.5	160	84	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
T-8A	A	J6039-T8A-101217	10/12/2017	0.50	46	110	1.7	6.0	<0.50	0.54	<0.50	<0.50	<0.50	<0.50	<0.50
T-9A	A	J6039-T9A-101017	10/10/2017	0.76	48	77	2.5	<0.50	<0.50	<0.50	<0.50	<0.50	2.3	<0.50	<0.50
T-13A	A	J6039-T13A-101117	10/11/2017	<0.50	41	91	3.4	11	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
T-14A	A	J6039-T14A-101117	10/11/2017	1.0	56	66	2.7	29	<0.50	<0.50	<0.50	<0.50	2.3	<0.50	<0.50
T-15A	A	J6039-T15A-101017	10/10/2017	1.8	110	82	7.5	<0.50	<0.50	0.87	<0.50	<0.50	1.4	<0.50	<0.50
T-16A	A	J6039-T16A-101617	10/16/2017	1.0	58	72	2.5	3.4	<0.50	0.81	<0.50	<0.50	1.5	<0.50	<0.50
T-17A	A	J6039-T17A-101217	10/12/2017	1.2	72	13	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
T-18A	A	Not sampled by AECOM - Not part of sampling and analysis plan													
T-19A	A	J6039-T19A-101117	10/11/2017	<0.50	<0.50	3.3	2.2	17	<0.50	<0.50	<0.50	<0.50	0.82	<0.50	<0.50
T-20A	A	Not sampled by AECOM - Not part of sampling and analysis plan													
T-21A	A	Not sampled by AECOM - Not part of sampling and analysis plan													
T-22A	A	Not sampled by AECOM - Not part of sampling and analysis plan													
T-23A	A	J6039-T23A-101117	10/11/2017	0.64 F1	78	55	1.3 F1	0.8 F1	<0.50 F1	<0.50 F1F2	<0.50	<0.50 F1F2	<0.50	<0.50	<0.50
T-25A	A	J6039-T25A-101317	10/13/2017	1.2	67	42	2.0	20	<0.50	<0.50	0.51	<0.50	2.6	<0.50	<0.50
365[1]	A	--	10/12/2017	1.5	68	9.8	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	-	-
365[1]	A	--	10/12/2017	< 0.50	4.2	5.2	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	-	-
36-S	A	J6039-365-101217	10/12/2017	<0.50	51	170	1.5	8.7	<0.50	0.62	<0.50	1.4	<0.50	<0.50	<0.50
Equator	A	Destroyed													
T-1B	B1	Destroyed													
T-2B	B1	Destroyed													
T-4B	B1	J6039-T4B-101317	10/13/2017	<0.50	5.2	650	2.7	0.62	<0.50	2.2	<0.50	<0.50	<0.50	<0.50	<0.50
T-5B	B1	J6039-T5B-101117-1	10/11/2017	<25	1500	54	<25	<25	<25	<25	<25	160	<25	<25	<25
T-5B Dup	B1	J6039-T5B-101117-2	10/11/2017	<50	1500	54	<50	<50	<50	<50	<50	170	<50	<50	<50
T-7B	B1	J6039-T7B-101117-01	10/11/2017	0.54	160	12	1.1	<0.50	<0.50	0.57	<0.50	4.1	2.0	<0.50	<0.50
T-7B Dup	B1	J6039-T7B-101117-02	10/11/2017	<5.0	160	2.7	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
T-9B	B1	J6039-T9B-101117	10/11/2017	<10	<10	4.08	<10	27	<10	<10	<10	<10	<10	<10	<10
T-10B	B1	J6039-T10B-101017	10/10/2017	1.7	310	260	2.5	21	<1.0	2.3	<1.0	1.9	<1.0	<1.0	<1.0
T-10B	B1	J6039-T10B-101617	10/16/2017	1.8	41	150	2.8	50	<0.50	0.94	0.86	<0.50	4.2	<0.50	<0.50
T-11B	B1	J6039-T11B-101217	10/12/2017	<5.0	310	370	<5.0	<5.0	<5.0	<5.0	<5.0	7.1	<5.0	<5.0	<5.0
T-18B	B1	J6039-T18B-101017	10/10/2017	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
T-19B	B1	J6039-T19B-101117	10/11/2017	<0.50	62	1.4	<0.50	<0.50	<0.50	<0.50	<0.50	1.1	<0.50	<0.50	<0.50
T-20B	B1	J6039-T20B-101017	10/10/2017	<5.0	220	280	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
T-21B	B1	J6039-T21B-101217	10/12/2017	<0.50	260	480	2.0	<0.50	<0.50	1.5	<0.50	16	<0.50	<0.50	<0.50
T-22B	B1	J6039-T22B-101317	10/13/2017	1.0	97	150	3.3	9.88	<0.50	0.81	<0.50	<0.50	3.0	<0.50	<0.50
T-23B	B1	J6039-T23B-101617	10/16/2017	1.3	86	150	2.7	9.84	<0.50	0.77	<0.50	<0.50	2.6	<0.50	<0.50
T-24B	B1	J6039-T24B-101317	10/13/2017	<0.50	88	130	1.4	4.0	<0.50	1.5	0.59	<0.50	<0.50	<0.50	<0.50
T-3C	B2	Destroyed													
T-10C	B2	J6039-T10C-101317	10/13/2017	<25	740	800	<25	<25	<25	<25	<25	140	<25	<25	<25
T-11C	B2	J6039-T11C-100917	10/9/2017	<0.50	310 H	28	0.64	2.5	<0.50	2.2	<0.50	19	<0.50	<0.50	<0.50
T-12C	B2	J6039-T12C-101617	10/13/2017	<0.50	140	9.3	0.98	<0.50	<0.50	1.5	<0.50	17	<0.50	<0.50	<0.50
36DC[1]	B2	--	10/12/2017	< 0.50	4.3	2.4	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	-	-
T-9C[2]	B3	J6039-T9C-101017	10/10/2017	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
T-8C	B4	Not sampled by AECOM - Water Board approval to discontinue sampling requirement for well													

Notes:
[1] Groundwater analytical data provided by AMD.
[2] This well has been redesignated as a Zone B3 well based on a detailed evaluation of the screen interval and lithology.

<	Not detected at or above the detection limit shown
µg/L	micrograms per liter
1,1,1-TCA	1,1,1-Trichloroethane
1,1-DCA	1,1-Dichloroethane
1,1-DCE	1,1-Dichloroethene
1,2-DCB	1,2-Dichlorobenzene
1,4-DCB	1,4-Dichlorobenzene
CBN	Chlorobenzene
cDCE	cis-1,2-Dichloroethene
Dup	Duplicate sample
J	Estimated concentration. Compound detected between the detection limit and the reporting limit.
PCE	Tetrachloroethene
tDCE	trans-1,2-Dichloroethene
TCE	Trichloroethene
Freon 113	Trifluorotrichloroethane
VC	Vinyl Chloride

Offsite OU

Groundwater within the Offsite OU did not progress substantially towards reaching the RAO of groundwater restoration within the review period. During the review period, dissolved concentrations of TCE, cDCE, and VC exceeded MCLs in one or more zones of the shallow aquifer. Groundwater flow direction is towards the north-northeast (Figure B-23) for the shallow aquifers (A and B zones). Mann-Kendall analysis indicates that TCE concentrations in all aquifer zones are elevated above the ROD cleanup levels and are stable or slightly decreasing (Table B-4). Elevated TCE in shallow groundwater continues to be a source for vapor intrusion into residences and schools above the dissolved TCE groundwater plume.

The following discussion of the Offsite OU TCE plume is primarily based upon extraction well data along residential streets set between about 600 and 900 feet apart that were installed between 1988 and 1992. The lack of data between these extraction areas make inferences of the internal characteristics of the TCE plume difficult.

Based on data presented in the 2017 Annual Monitoring Report, the remedy appears to be providing horizontal hydraulic control of contaminant migration in groundwater from upgradient sources. Comparison of the 2010 TCE plume (Figure B-24) and 2017 TCE plume (Figure B-25) show modest reduction in plume size. The concentration footprint of the plume has not significantly changed indicating containment is occurring. The groundwater flow direction at the southern portion of the plume has changed following startup of the AMD 915 Site extraction wells, possibly indicating limited or incomplete capture along the eastern property boundaries (Figure B-25). However, the methodology used to evaluate the capture areas (EPA, 2008) was not applied consistently, evaluation of vertical gradients did not account for the vertical separation of the measuring points and was, in part, based on water levels measured in pumping wells.

Furthermore, there is a wide gap in in the level of detail and accuracy of the Conceptual Site Model for the Offsite OU and the TRW Site, which should be narrowed to be able to achieve greater success in mass removal, leading to aquifer restoration and mitigation of risks to human health and the environment. The Conceptual Site Model needs to be updated to account for the preferred transport pathways of the fluvial depositional environment known to exist in the region. The Conceptual Site Model update should include the following activities: regional pre-remediation hydraulic gradients should be estimated; a detailed review of lithologic changes from boring logs should be conducted; permeability zones should be identified and identified thicknesses; detailed cross-sections that map out high permeability zones should be constructed; and new subsurface chemical and stratigraphic data should be assimilated where appropriate.

Additional investigation is also needed to define the extent of the TCE plume for the A and B1 aquifer zones near Blythe Avenue and north of Lakehaven Drive and address the large data gaps that exist in these two shallow aquifer zones between the groundwater extraction well clusters along Duane, Alvarado, and Ahwanee Avenues (Figures B-25 and B-26). Preferred contaminant migratory pathways, similar to and including those identified at the Signetics and TRW Sites, have yet to be evaluated for the Offsite OU. These areas of uncertainty should be addressed to provide a higher level of confidence that the plume

in all affected aquifers has been adequately characterized and that the current groundwater remedy is adequate to control contaminant migration and that extraction is optimized to remove contaminant mass and reduce the TCE inhalation risks to occupants of overlying residences and school buildings.

The lack of data on groundwater VOC concentrations between the extraction well clusters along Duane and Alvarado Avenues is manifested by various plume configuration maps primarily for the A and B1 Zones (Figures B-25 and B-26). In regard to the A Zone, prior to 2011, the greater than 100 microgram per liter (µg/L) TCE contour that reflects the primary downgradient migration pathway for VOCs passed west of well COM01A. In 2011, this primary pathway changed, as depicted on the maps generated by the RP, from west of well COM01A to the east of that well with no appreciable change in VOC concentrations in groundwater along and between Duane and Alvarado Avenues. Similarly, the drastic reduction in the 100 µg/L contour from 2017 to 2018, as depicted on the maps generated by the RP, appears to be dependent upon the decrease in TCE levels in two extraction wells along Duane and Alvarado Avenues with no substantiating data between these locations. The lack of data between Duane and Alvarado Avenues constitutes a major data gap as TCE concentrations in the A Zone is the primary contributor to vapor intrusion risk.

Similar to the uncertainties in the A Zone, ambiguities in the concentration of VOCs in the B1 Zone between Duane and Alvarado Avenues coupled with the lack of information on the vertical hydraulic gradient between the A and B1 Zones constituents a second major data gap. The greater than 100 µg/L contour, as depicted in 2010 by the RP, was continuous between Duane and Alvarado Avenues. However, despite the fact that wells along and between Duane and Alvarado Avenues continued to show TCE levels above 100 µg/L, the 100 µg/L contour, as depicted by the RP, was fragmented and disappeared between Carmel and Duane Avenues. This fragmentation persisted such that the 2018 100 µg/L contour, as depicted by the RP, is present only about individual wells, despite TCE levels above 100 µg/L currently present along Duane, Carmel, and Alvarado Avenues. The uncertainty in the distribution of dissolved TCE between Duane and Alvarado Avenues is a second major data gap.

Additional data to eliminate uncertainties in the A and B1 zones and update the CSM by identifying migratory pathways coupled with numeric modeling of groundwater extraction could expedite groundwater restoration and reduce potential vapor intrusion risks to overlying residences and school buildings. While recognizing that there is a high potential for subsurface complexities at the Signetics Site and Offsite OUs, the current understanding of the subsurface, as presented in the RP's Annual Reports (Locus, 2017, 2018, 2019), is highly simplified and does not actually account for the potential for highly channelized flow and the subsequent control such preferential flow pathways would have on the plume geometry in three dimensions. Therefore, greater subsurface detail is needed to identify and adequately map the potential migration pathways, such that the Offsite OU plume geometry and configuration can be better understood and remedied. Furthermore, once the subsurface is adequately characterized, plume capture can be evaluated using groundwater flow and transport modeling. Flow and transport modeling can also be used to establish the expected long-term effectiveness of the implemented remedy and used to support planned revisions to the existing remedy.

The lack of significant reduction in TCE in the shallow aquifers appears in part a result of the remedy strategy implemented that concentrated on inducing hydraulic gradients (flow) from groundwater with higher concentrations to groundwater with lower concentrations ensuring vertical containment of the

plumes and not necessarily removal of TCE from the shallow aquifer zones. The vertical gradient in areas removed from active groundwater extraction in the Offsite OU is not well known as some areas appear to exhibit an upward gradient from the B1 zone to the A zone and other areas show the reverse. Additional data on the vertical gradient in Offsite OU in areas removed from the extraction wells are needed to confirm that an upward gradient does not exist that routes elevated TCE in B1 zone groundwater into less impacted A zone groundwater.

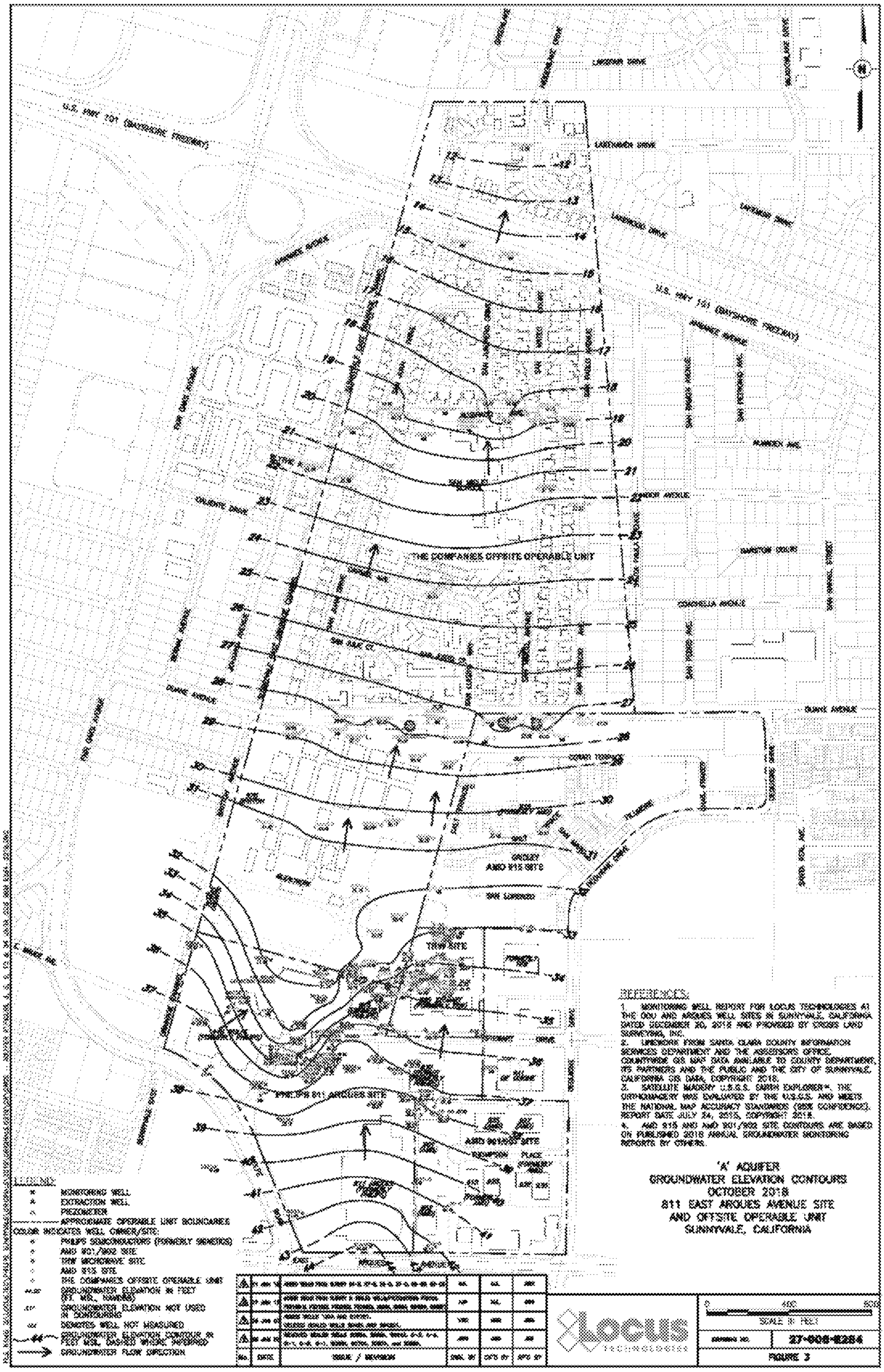
The GWETS for the Offsite OU is generally maintaining plume control, however, evidence suggests that without improvements in the remedial strategy, no significant reduction in the footprint of the groundwater VOC plume or control of chemical contaminant vapor emissions from shallow groundwater will occur in any reasonable timeframe.

Review of the 2018 Annual Groundwater Monitoring Report for the OOU (Locus, 2019) and the 2016 Conceptual Site Model for the adjacent TRW Microwave Site reveals the wide gap in site knowledge and understanding between the two sites which should be narrowed. Without a complete Conceptual Site Model site conceptual model of the Offsite OU and Signetics Site that it is at least as detailed at those developed for the AMD and TRW Sites, it will not be possible to understand if control of the contamination plumes has been achieved or to adequately plan for design changes required to meet the remedial objectives. Channelized preferred pathways were historically identified on the Signetics Site for portions of the A and B aquifer zones but were not further investigated or expanded to other zones.

While recognizing there is a high potential for subsurface complexities at the Signetics and Offsite OUs, the current understanding of the subsurface is simplified and does not account for the potential for highly channelized flow and the subsequent control such preferential flow pathways would have on the plume geometry in three dimensions. Therefore, greater detail of the subsurface is needed to identify and adequately map the potential migration pathways such that the Offsite OU plume geometry, configuration, and chemical content can be better understood and adequately remediated. Furthermore, once the subsurface is adequately characterized, plume capture can be evaluated using groundwater flow and transport modeling. Flow and transport can also be used to establish the expected long-term effectiveness of the implemented remedy.

Table B-4. Mann-Kendall Trend Analysis Results for TCE in the Offsite OU from 2007 to 2017

Well ID	GW Zone	n	Coefficient of Variation	MK Statistic	Confidence Factor (%)	2017 TCE Concentration (ug/l)	Trend
Southern Portion of Plume (downgradient of Signetics)							
S075A2	A	11	0.62	-28	98.4	140	Decreasing
S057B	B1	11	2.42	-35	99.7	1	Decreasing
Duane Avenue							
COM06A	A	11	0.19	-27	98	180	Decreasing
COM06B2	B2	11	0.15	-10	75.3	540	Stable
COM09B3	B3	11	0.13	-25	97	580	Decreasing
Center of Plume South of San Miguel School							
COM01A	A	11	0.47	-10	75.3	29	Stable
COM01B1	B1	11	0.16	-17	89.1	130	Stable
COM01B2	B2	11	0.1	-11	77.7	210	Stable
Center of Plume East of San Miguel School							
COM04A	A	11	0.13	-22	94.9	26	Probably decreasing
Blythe Avenue - west San Miguel School - Offsite							
COM55A	A	11	0.34	-5	61.9	14	Stable
Center of Plume North of San Miguel School							
COM03A	A	11	0.1	-17	89.1	120	Stable
COM03B	B1	11	0.1	-17	89.1	57	Stable
COM03B2	B2	11	0.11	8	70.3	250	No Trend
COM06B3	B3	11	0.1	-23	95.7	440	Decreasing
COM06B4	B4	11	0.24	-3	56	89	Stable
Furthest downgradient & Offsite							
COM63-B1	B1	11	0.59	-46	99.9	22	Decreasing



U.S. HWY 101 (BAYSHORE FREEWAY)
THE COMPANIES OFFSITE OPERABLE UNIT
TRW SITE
AMD 915 SITE
PHILIPS 811 ARQUES SITE
AMD 901/902 SITE
'A' AQUIFER
GROUNDWATER ELEVATION CONTOURS
OCTOBER 2018
811 EAST ARQUES AVENUE SITE
AND OFFSITE OPERABLE UNIT
SUNNYVALE, CALIFORNIA
LOCUS TECHNOLOGIES
SCALE IN FEET
FIGURE 3

Figure B-23. A Zone Water Elevations Contours for the Offsite OU and Nearby Sites

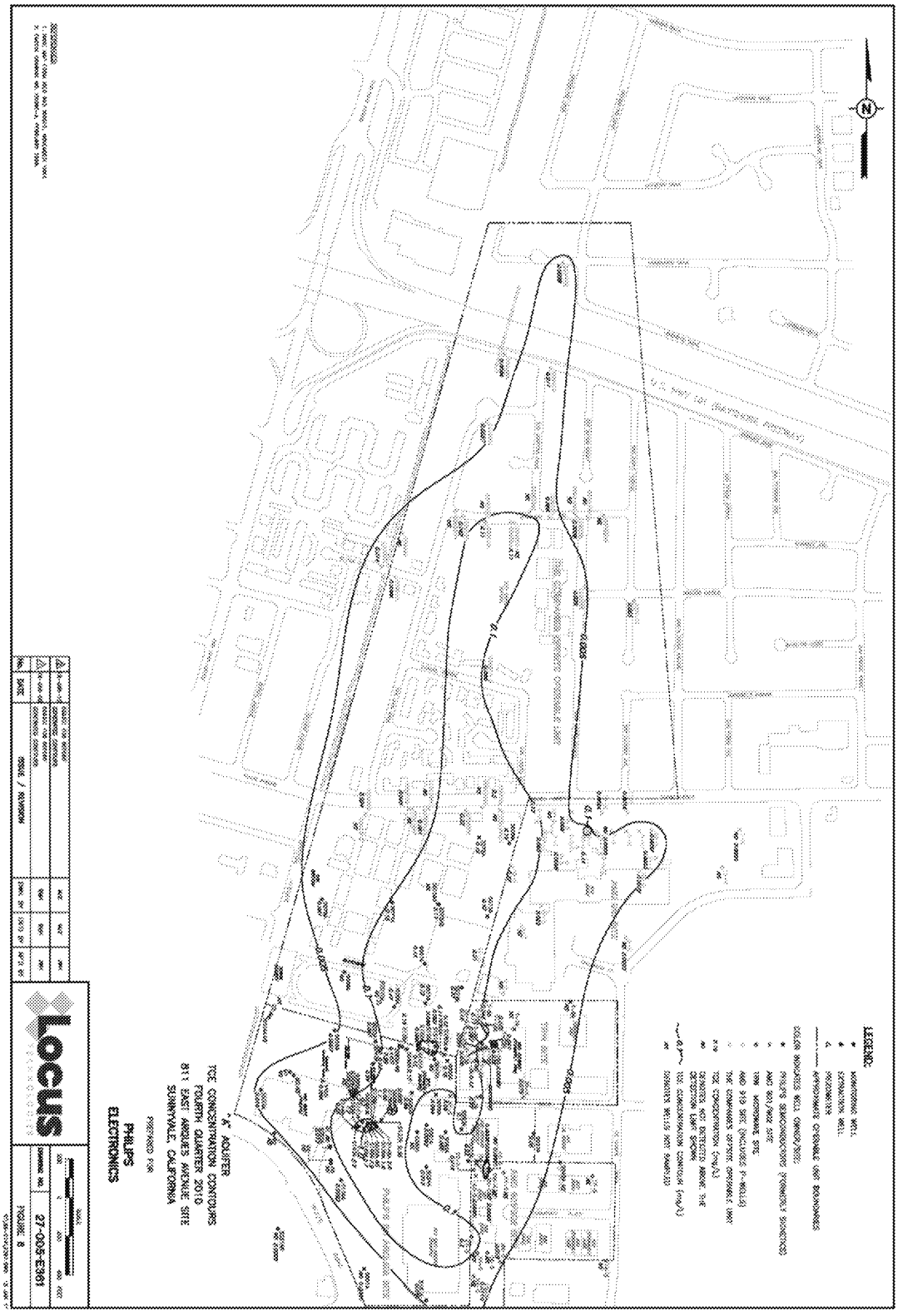


Figure B-24. TCE Concentrations A Zone 2010

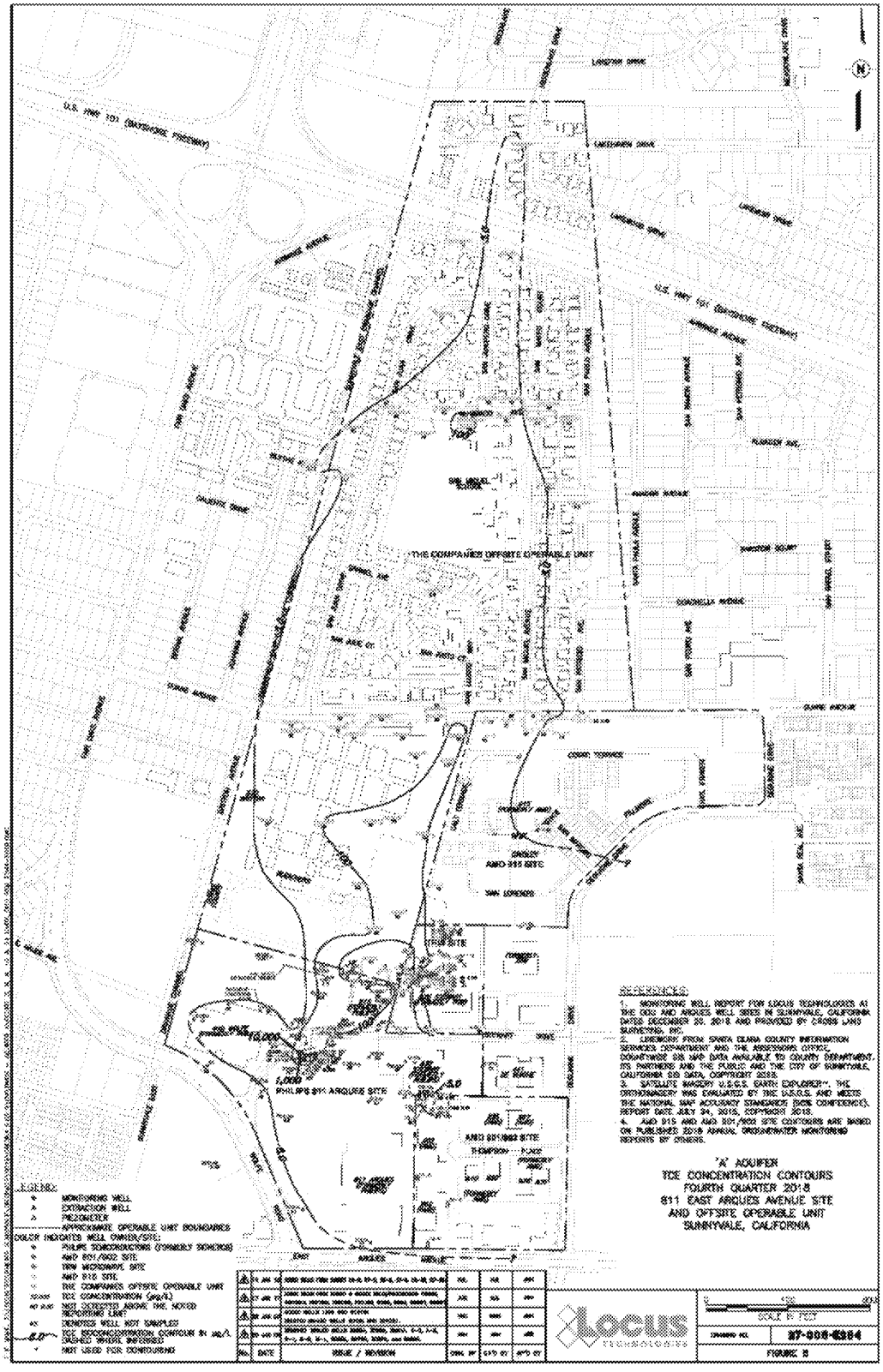


Figure B-25. TCE Concentrations A Zone 2018

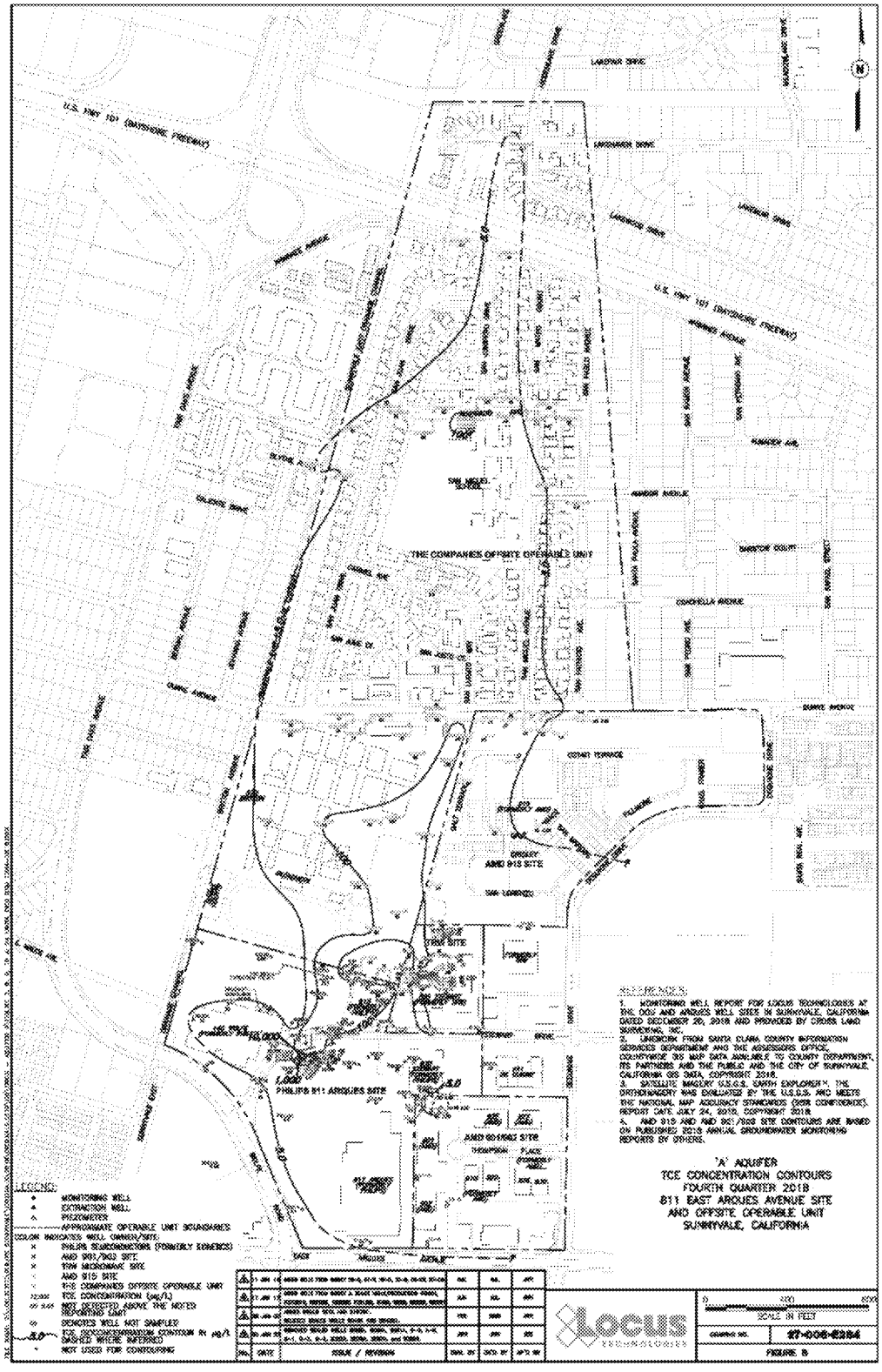
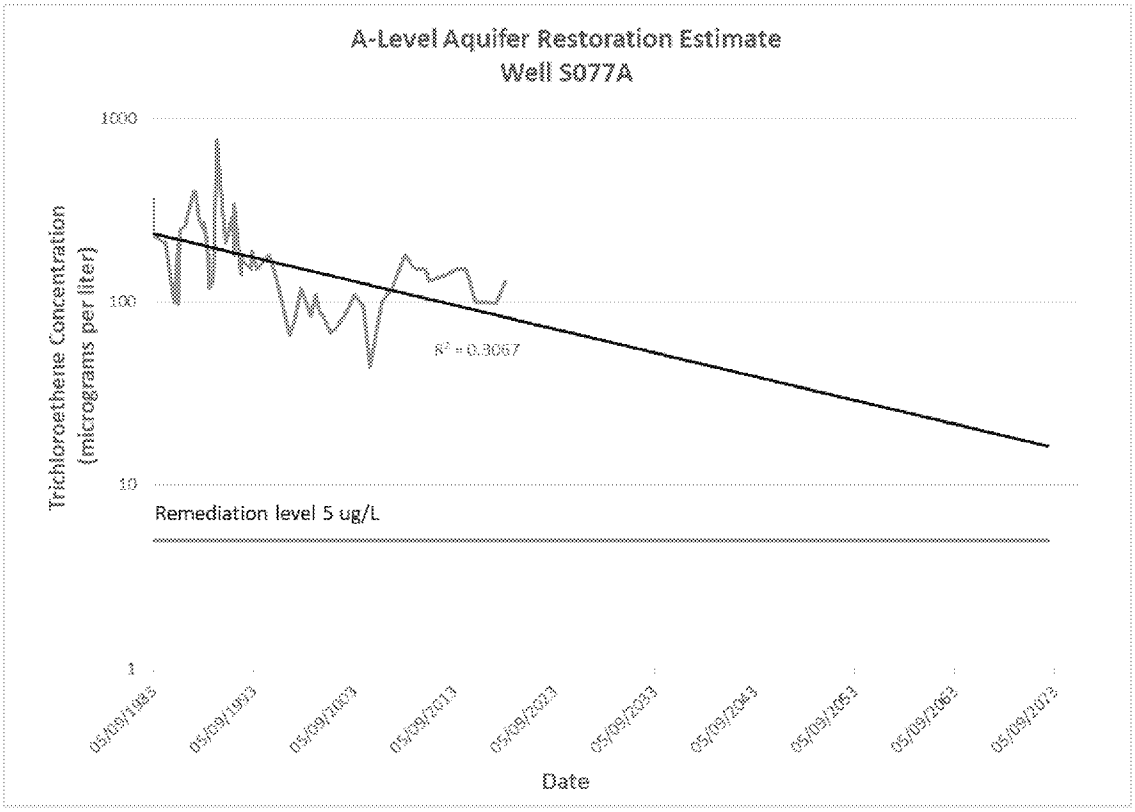
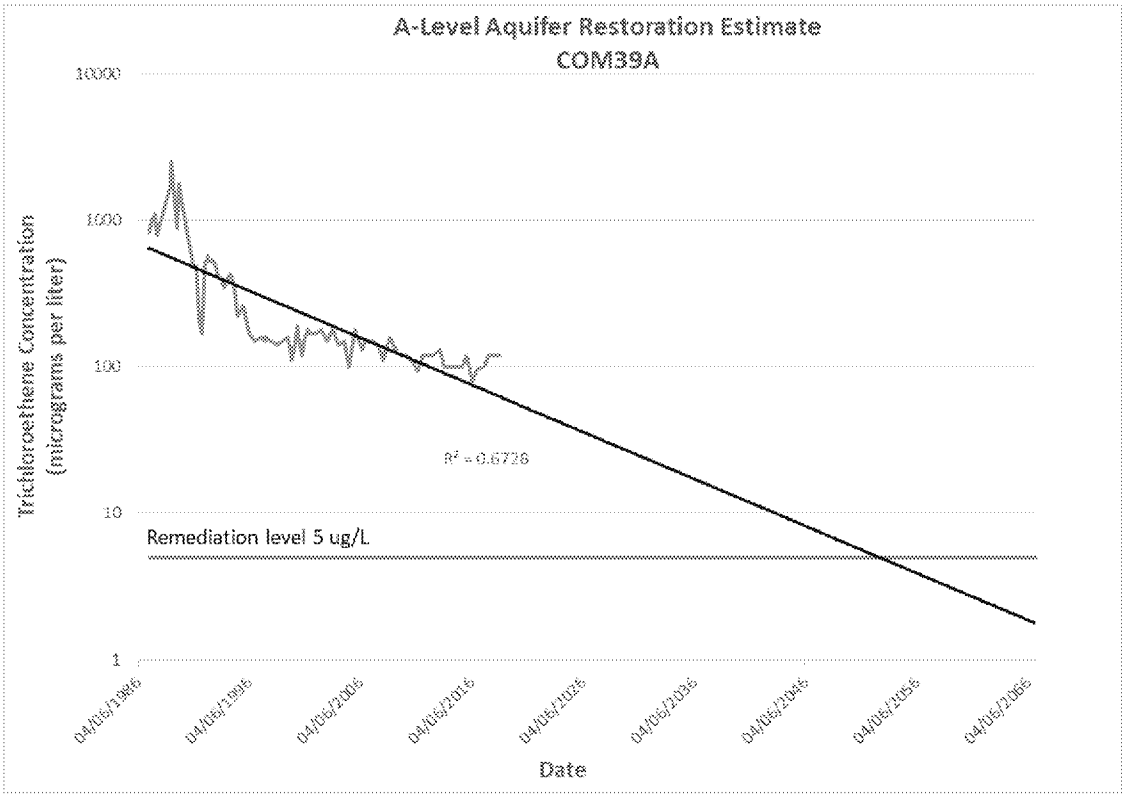
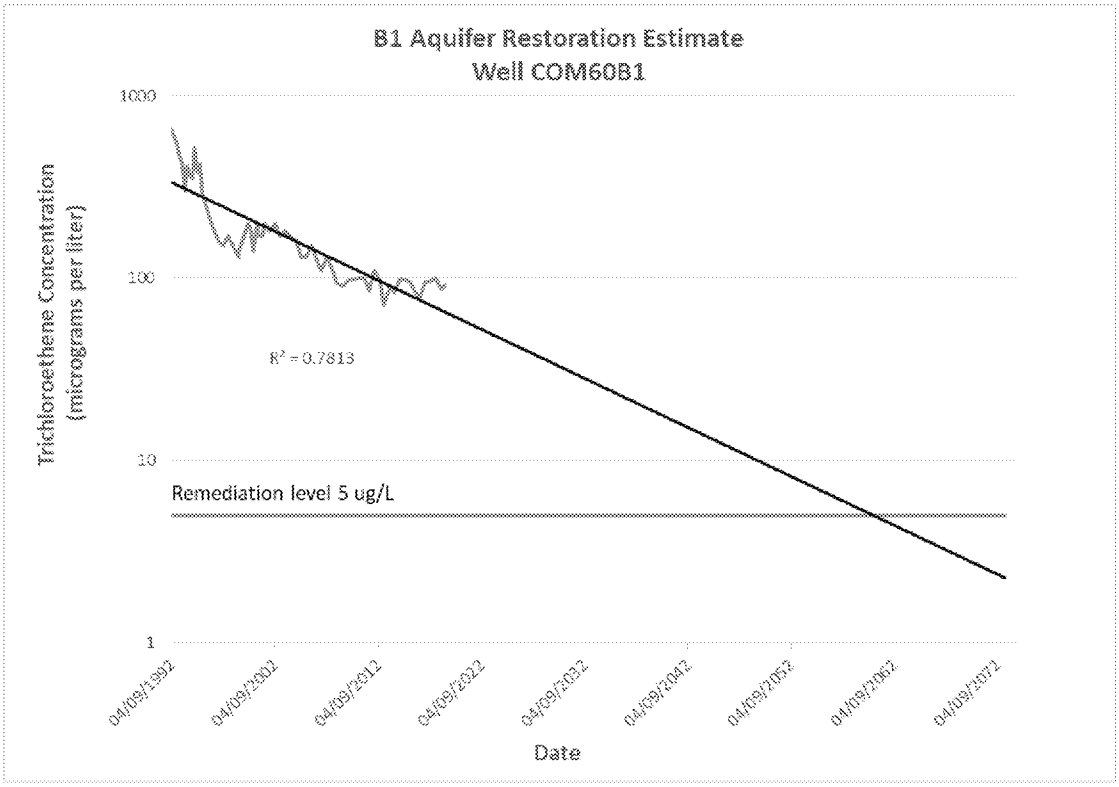
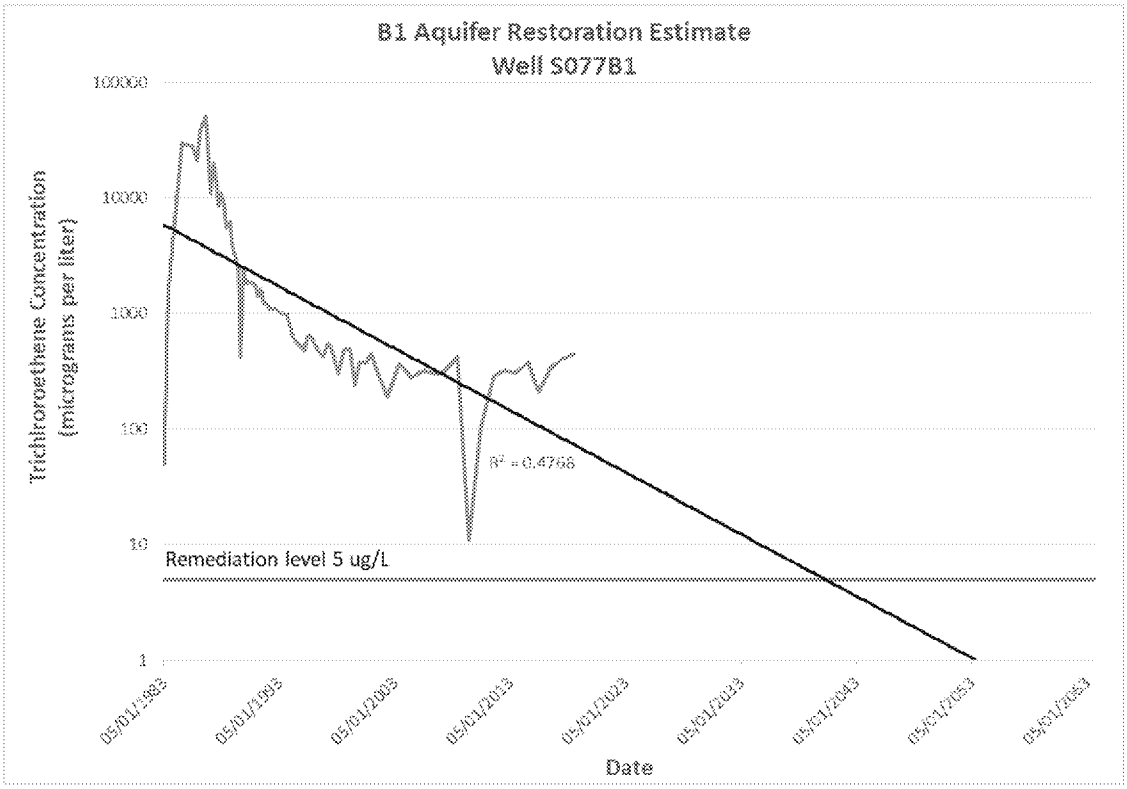


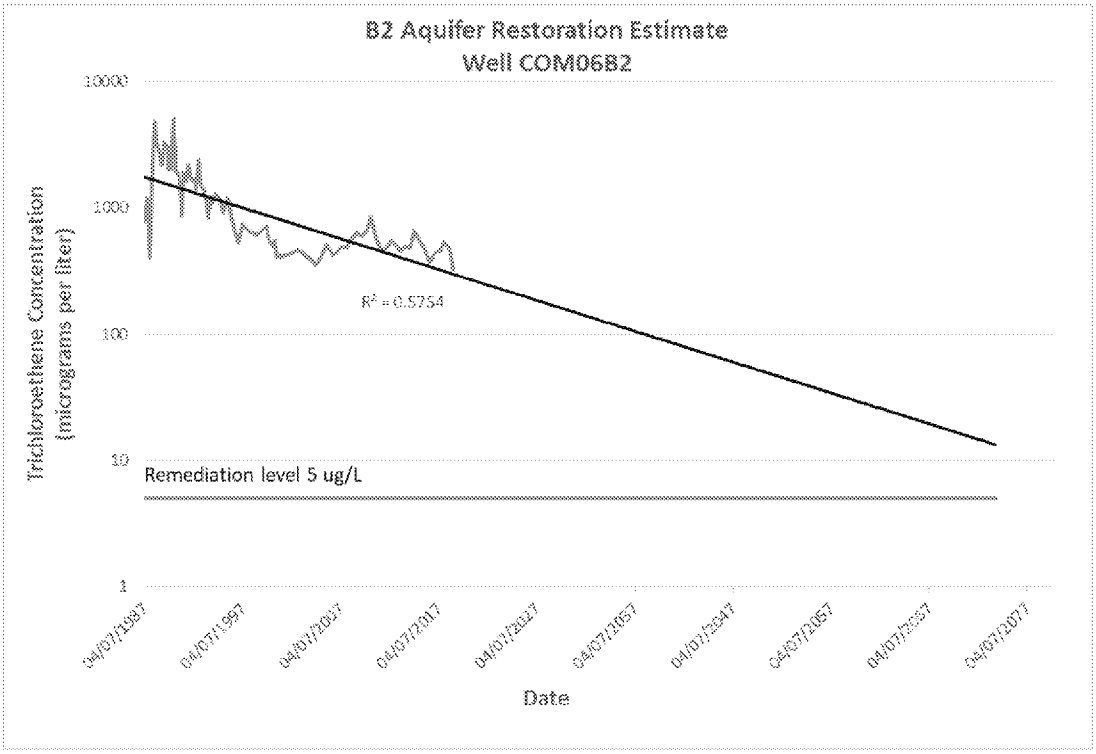
Figure B-26. TCE Concentrations B1 Zone 2018

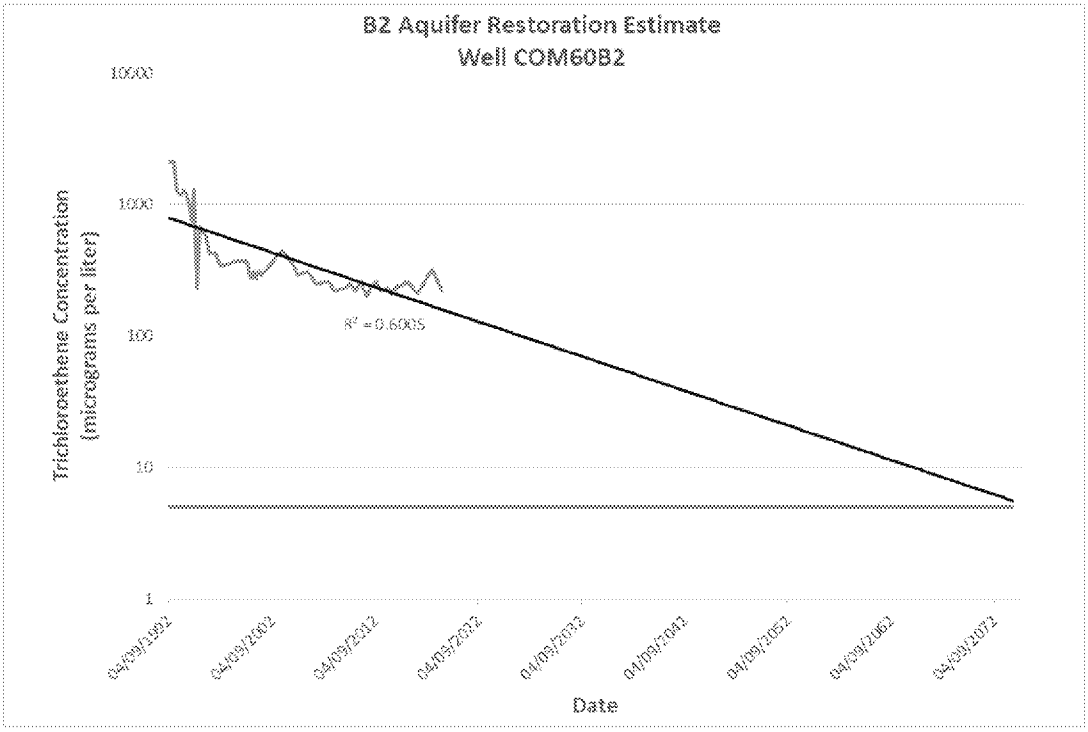












Vapor Intrusion

Offsite OU Residential Buildings

Residential indoor air vapor intrusion sampling in the Offsite OU under EPA oversight began in January 2015 and is ongoing. As of April 26, 2018, a total of 225 households in 134 buildings were sampled (Aptim Federal Services, 2019).

Residential sampling data was organized into five groups (Groups 1 through 5) that relate the TCE indoor air sampling results and building location to the underlying TCE groundwater plume. The TCE plume is defined by the area where TCE levels in groundwater exceed the EPA's MCL of 5.0 micrograms per Liter (µg/L). Sampling data was compared to EPA's long-term residential RSL for indoor air of 0.48 micrograms per cubic meter (µg/m^3) and EPA's short-term residential RSL of 2.0 µg/m^3. Multiple lines-of-evidence were used to determine if the TCE levels detected were due to vapor intrusion, attributable to elevated outdoor air TCE levels, or related to a confounding indoor source of TCE.

Group 1 households (which total 33) are in buildings located *outside* of the shallow groundwater TCE plume as contoured by the RP, based upon the current data set, and defined by the MCL of 5.0 µg/L, but *within or in very close proximity to the Offsite OU* as it is defined in the ROD. Group 1 residences show *no evidence of unacceptable vapor intrusion*, i.e., have TCE results less than the long-term screening level of 0.48 µg/m^3, or TCE results between 0.48 and the short-term screening level of 2.0 µg/m^3, but likely non-vapor intrusion related, for example, attributable to elevated outdoor air TCE levels or an indoor source.

Similar to Group 1, Group 2 households (which total 97) are in buildings showing *no evidence of unacceptable vapor intrusion.* However, Group 2 residences are located *directly over* the shallow groundwater TCE plume.

Group 3 households (which total two) are in buildings located *directly over* the groundwater TCE plume with indoor air TCE results *showing some evidence of vapor intrusion, but within EPA's Superfund health-protective risk management range* of 0.48 to 2.0 µg/m^3.

Residences falling within Groups 1 through 3 have been identified by EPA as warranting no further action with respect to the vapor intrusion pathway.

Group 4 households (which total 31) are in buildings located *directly over* the groundwater TCE plume with TCE results *showing evidence of unacceptable vapor intrusion, exceeding the short-term screening level of 2 µg/m^3, warranting mitigation*. For these buildings showing a need for mitigation, TCE in the nearest shallow groundwater monitoring wells was detected at levels of 20 – 30 µg/L and above. Mitigation efforts at these buildings are underway, specifically, installation of active sub-slab and sub-membrane depressurization systems and post-mitigation sampling and maintenance plans to confirm continued effectiveness of the mitigation systems. As of the writing of this FYR, mitigation systems in 10 residential buildings (single-family residences and multi-family apartment complexes) have been installed.

To confirm the effectiveness of the mitigation systems, indoor air samples are collected as part of the EPA-approved Operation, Maintenance and Monitoring (OMM) plans, tailored to each building. Indoor air samples are collected two weeks and 30 days following initial system installation and then during the subsequent winter, spring, and second winter of operation. Additionally, maintenance inspections are conducted on a quarterly basis during the first year of system operation (and may be reduced to annually thereafter, depending on the results of the first year of inspections) and after significant weather events. Also, mitigation systems are equipped with auto-dialers that alert the RP contractor's technicians should there be any malfunctions, or if the system is turned off.

Group 5 households (which total 62) are in buildings located *directly over* the groundwater TCE plume where *preemptive mitigation has been completed or is currently under consideration* to address potential unacceptable vapor intrusion. Similar to Group 4 residences (which showed evidence of unacceptable vapor intrusion), Group 5 residences are also located in *close proximity* to shallow groundwater monitoring wells showing TCE at levels of 20 – 30 µg/L and above. TCE results in Group 5 residences were either elevated as compared to outdoor air TCE levels, showing some evidence of vapor intrusion, but less than the short-term screening level of 2.0 $\mu g/m^3$ or in close proximity to and of similar construction to a Group 4 building.

Offsite OU School Buildings

TCE indoor air vapor intrusion sampling at school buildings in the Offsite OU under EPA oversight began in January 2015 and is ongoing. A total of four schools, including 40 buildings, have been sampled under both heating and ventilation systems (HVAC)-off and HVAC-on conditions. Unacceptable levels of vapor intrusion were detected in eight school buildings, at which mitigation measures were implemented to prevent elevated levels of TCE vapors from accumulating indoors. In addition, preemptive mitigation systems were installed in four school buildings, three of which were new buildings where the mitigation systems were integrated into the new construction.

Mitigation measures in school buildings included the installation of active, sub-slab and sub-membrane depressurization systems, operation of indoor air purifiers, upgrades and operational modifications to HVAC systems, sealing of conduits, and the installation of one-way floor drains.

To confirm the effectiveness of the mitigation systems, indoor air samples are collected as part of the EPA-approved Operation, Maintenance and Monitoring (OMM) plans, tailored to each building. Indoor air samples are collected two weeks and 30 days following initial system installation and then during the subsequent winter, spring, and second winter of operation. Additionally, maintenance inspections are conducted on a quarterly basis during the first year of system operation (and may be reduced to annually thereafter, depending on the results of the first year of inspections) and after significant weather events. Also, mitigation systems are equipped with auto-dialers that alert the RP contractor's technicians should there be any malfunctions, or if the system is turned off.

Summaries of indoor and pathway air sample results from all 40 school buildings collected between January 2015 and April 2018 are shown in the following tables. The data tables present the range of TCE concentrations (minimum – maximum) over the specified date ranges.

For the school buildings with mitigation systems installed where sampling results have been received (as of April 2018), all indoor air TCE concentrations from the most recent set of post-mitigation samples are either below EPA's long-term screening level of 0.48 micrograms per cubic meter ($\mu g/m^3$) or similar to outdoor air TCE levels during the corresponding sampling events, indicating that the mitigation systems are working properly to prevent unacceptable vapor intrusion from occurring.

San Miguel Elementary School and California Young World

During the 2015 HVAC-on and -off sampling events, indoor air samples collected from certain locations at San Miguel Elementary School and the adjacent California Young World after-school childcare building indicated some evidence of vapor intrusion. Sample results are presented in Appendix B. Elevated TCE concentrations above EPA's long-term screening level were present, although all results were within EPA's Superfund health-protective risk management range for TCE. Out of an abundance of caution and in light of the sensitive population potentially at risk, an active vapor intrusion mitigation system was installed at California Young World Daycare in 2015. Post-mitigation results at California Young World Daycare were all below EPA's long-term RSL and showed no evidence of vapor intrusion, indicating the mitigation system is working properly to prevent unacceptable vapor intrusion from occurring.

San Miguel Elementary completed construction of three new classroom buildings in 2017, including Buildings K, L-1, and L-2. Preemptive passive venting mitigation systems were integrated into the construction of these new buildings, with the capability of conversion to active depressurization status in the future if sampling results indicated a need. Three rounds of HVAC-on post-mitigation sampling were conducted. All of the indoor air TCE results were below EPA's long-term RSL. TCE was detected in samples at slightly elevated levels of up to 0.60 $\mu g/m^3$, but within EPA's Superfund health-protective risk management range for TCE.

In January and February 2018, EPA oversaw additional rounds of HVAC-on and -off indoor and pathway air sampling at the eight San Miguel Elementary buildings without mitigation systems. Three of the buildings tested (Main Office, Library, and Cafeteria/Multi-Purpose Room) yielded sampling results below EPA's long-term RSL, showing no evidence of vapor intrusion. Four of the buildings tested (Buildings A, C, D, and the Kindergarten Building) showed slightly elevated levels of TCE, above EPA's long-term RSL but within EPA's Superfund health-protective risk management range for TCE. Of these four buildings, one building – Building D (aka MC) – showed HVAC-off indoor air TCE levels of up to 1.7 $\mu g/m^3$ (outdoor air TCE at non-detect), though HVAC-on indoor air TCE levels were lower – up to 0.7 $\mu g/m^3$ (outdoor air TCE at 0.42 $\mu g/m^3$).

One building showed HVAC-off indoor air TCE levels of up to 2.2 $\mu g/m^3$, exceeding EPA's short-term RSL. At this building, no HVAC-on indoor air TCE results exceeded 2.0 µg/m3. An active mitigation system was installed in this building.

KinderCare Learning Center

EPA oversaw HVAC-on and -off indoor and pathway air sampling at the KinderCare Learning Center from January 2015 to February 2018. Indoor and pathway air results consistently showed no indication of

vapor intrusion. All of the samples yielded either non-detectable or very low levels of TCE (up to 0.28 $\mu g/m^3$), none of which exceeded EPA's long-term RSL.

Rainbow Montessori Child Development Center

EPA oversaw indoor and pathway air sampling at the Rainbow Montessori Child Development Center in 2015 and 2016. Results indicated that vapor intrusion was occurring in certain classrooms in all five school buildings. TCE was detected at levels of up to 16 $\mu g/m^3$ in indoor air (Building L in January 2015) and at levels of up to 14 $\mu g/m^3$ in pathway air (Building L in January 2015).

Following the receipt of these sampling results, EPA oversaw a series of interim response measures to reduce the TCE levels in the school buildings. These measures consisted of HVAC inspections, modifications, upgrades, and communications to staff regarding the temporary ventilation measures. Communications to school staff included the importance of maintaining the new HVAC settings to bring outdoor air into the classrooms. Additionally, staff were advised to avoid altering HVAC settings with in-room thermostat changes.

Regular indoor air sampling was conducted throughout the school to confirm the protectiveness of the interim measures. Indoor air TCE concentrations decreased as a result of these ventilation improvements and subsequent HVAC upgrades throughout the campus. Indoor air TCE levels throughout this time were generally within EPA's health-protective risk range, or, if slightly elevated above the risk range, likely influenced by contributions from outdoor air TCE levels measured during the sampling periods.

EPA oversaw the installation of permanent mitigation systems in all five Rainbow Montessori Child Development Center buildings beginning in April 2017. Installations were completed in May 2017. Post-mitigation sampling results for these buildings were all within EPA's health-protective risk range for TCE. Some samples were slightly elevated above EPA's long-term RSL, but likely influenced by contributions from outdoor air TCE levels measured during the sampling periods. Overall, the post-mitigation sampling results show no evidence of vapor intrusion and indicate that all five mitigation systems are working properly.

The King's Academy

EPA oversaw HVAC-on and -off indoor and pathway air sampling at the 19 school buildings that make up The King's Academy campus during 2015 and 2018. TCE concentrations in indoor and pathway air varied significantly among the buildings.

During the 2015 and 2016 sampling events, 10 of the 19 buildings yielded sampling results below EPA's long-term RSL, showing no evidence of vapor intrusion. In addition, three buildings resulted in slightly elevated levels of TCE above EPA's long-term RSL. However, these concentrations are within EPA's Superfund health-protective risk management range for TCE.

Two buildings (the Small Auxiliary Gym and the Auditorium Building) showed concentrations exceeding EPA's short-term RSL for TCE. In the Small Auxiliary Gym with a slab-on-grade foundation, TCE was detected in indoor air at levels of up to 2.7 $\mu g/m^3$ during the January 2016 sampling event. An active sub-slab mitigation system was subsequently installed at this building. The post-mitigation sampling results following this effort were all within or below EPA's health-protective risk range. The sets of results that

were slightly elevated above the low-end of the risk range were consistent with outdoor air TCE levels during the sampling periods, indicating the effectiveness of the mitigation system.

In the Auditorium Building, TCE was detected in pathway air (underneath the stage near a floor drain) at levels above 68 $\mu g/m^3$. The auditorium building contains a stage, auditorium-style seating, and slanted sub-grade construction. Indoor air samples showed much lower concentrations of TCE – up to 1.0 $\mu g/m^3$ (HVAC-off) and up to 0.7 $\mu g/m^3$ (HVAC-on), consistent with outdoor air TCE levels measured during the sampling periods.

Following the receipt of these results, an indoor air purifier was installed beneath the stage. Samples collected after the air purifier began operation showed somewhat lower TCE concentrations – levels of 34 $\mu g/m^3$. Additionally, a one-way drain plug was installed in the floor drain. Signs were posted to restrict entry to the sub-stage area. As of the writing of this FYR, a permanent mitigation system for this building is in the design stage.

Appendix C: ARAR Assessment

Section 121(d) (1) (A) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that remedial actions at CERCLA sites attain (or justify the waiver of) any Federal or state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Federal ARARs may include requirements promulgated under any Federal environmental laws. State ARARs may only include promulgated, enforceable environmental or facility-siting laws of general application that are more stringent or broader in scope than Federal requirements and that are identified by the State in a timely manner. ARARs are identified on a site-specific basis from information about the chemicals at the site, the RAs contemplated, the physical characteristics of the site, and other appropriate factors. ARARs include only substantive, not administrative, requirements and pertain only to onsite activities. There are three general categories of ARARs: chemical-specific, location-specific, and action-specific.

Chemical-specific ARARs identified in the selected remedy within the RODs and subsequent ROD Amendments for the groundwater at this Site and considered for this FYR for continued groundwater treatment.

Table C-1. Summary of Groundwater ARAR Changes

Contaminants of Concern	Applicable OU	1991 ROD cleanup goals (µg/L)	State MCL (µg/L)	Federal MCL (µg/L)	Is the cleanup goal above the current MCL?
1,1-DCA	All	5	5	NA	No
1,2-DCB	AMD, TRW	600	600	600	No
cDCE	All	6	6	70	No
tDCE	All	10	10	100	No
1,1-DCE	All	6	6	7	No
Freon 113	All	1200	1200	NA	No
PCE	AMD, TRW, Offsite	5	5	5	No
TCE	All	5	5	5	No
1,1,1-TCA	All	200	200	200	No
Vinyl chloride	AMD, TRW, Signetics	0.5	0.5	2	No

There have been no changes to chemical-specific ARARs over the last five years. All chemical cleanup goals remain below their respective state and Federal MCLs.

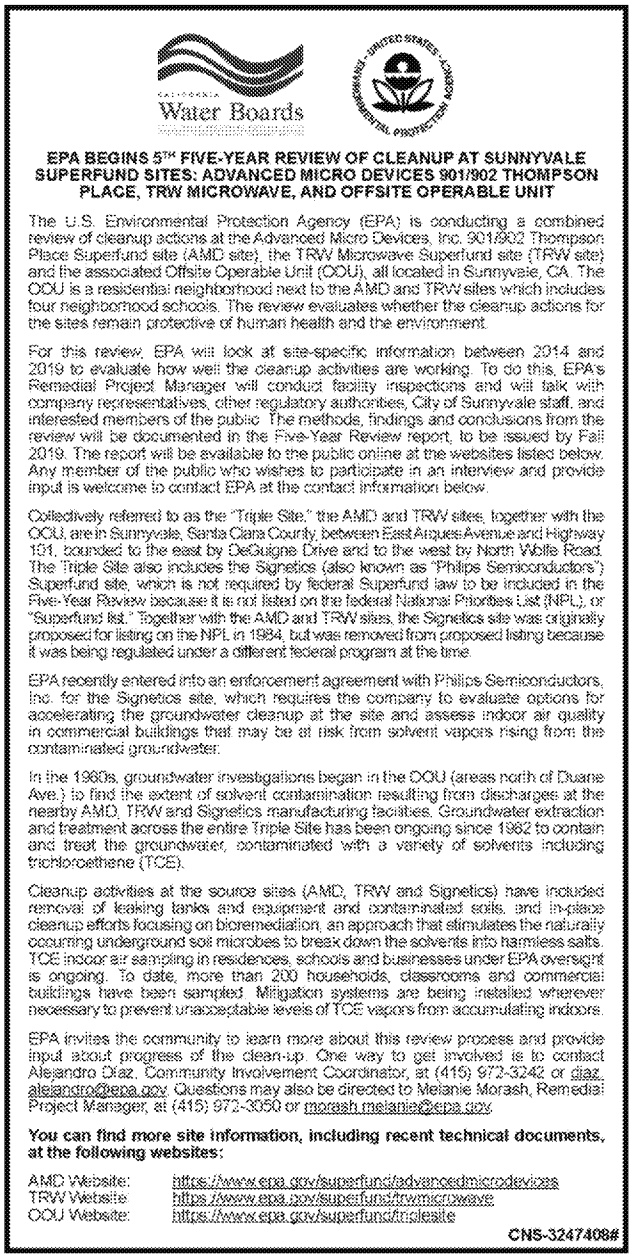
No Federal or State laws or regulations, other than the chemical-specific ARARs, have promulgated or changed over the past five years. There are several ARARs identified in the 1991 ROD that are no longer pertinent to the AMD and TRW Sites and Offsite OU. Several original ARARs pertaining to air emissions from air strippers are no longer applicable at the AMD and TRW sites because air stripping is no longer used. Additionally, there have been no revisions to laws or regulations that affect the protectiveness of the remedy.

The following ARARs have not changed since the last Five-Year Review; and therefore, do not affect protectiveness:

- National Pollutant Discharge Elimination System (NPDES)
- EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-28
- Bay Area Air Quality Management District (BAAQMD) Regulation 8. Rule 47
- Bay Area Air Quality Management District (BAAQMD) Regulation 8. Rule 40
- Resource Conservation Recovery Act (RCRA) Land Disposal Restrictions
- Clean Water Act
- Fish and Wildlife Coordination Act

Appendix D: Press Notice

Published in the *Sunnyvale Sun*



Water Boards

EPA BEGINS 5TH FIVE-YEAR REVIEW OF CLEANUP AT SUNNYVALE SUPERFUND SITES: ADVANCED MICRO DEVICES 901/902 THOMPSON PLACE, TRW MICROWAVE, AND OFFSITE OPERABLE UNIT

The U.S. Environmental Protection Agency (EPA) is conducting a combined review of cleanup actions at the Advanced Micro Devices, Inc. 901/902 Thompson Place Superfund site (AMD site), the TRW Microwave Superfund site (TRW site) and the associated Offsite Operable Unit (OOU), all located in Sunnyvale, CA. The OOU is a residential neighborhood next to the AMD and TRW sites which includes four neighborhood schools. The review evaluates whether the cleanup actions for the sites remain protective of human health and the environment.

For this review, EPA will look at site-specific information between 2014 and 2019 to evaluate how well the cleanup activities are working. To do this, EPA's Remedial Project Manager will conduct facility inspections and will talk with company representatives, other regulatory authorities, City of Sunnyvale staff, and interested members of the public. The methods, findings and conclusions from the review will be documented in the Five-Year Review report, to be issued by Fall 2019. The report will be available to the public online at the websites listed below. Any member of the public who wishes to participate in an interview and provide input is welcome to contact EPA at the contact information below.

Collectively referred to as the "Triple Site," the AMD and TRW sites, together with the OOU, are in Sunnyvale, Santa Clara County, between East Arques Avenue and Highway 101, bounded to the east by DeGuigne Drive and to the west by North Wolfe Road. The Triple Site also includes the Signetics (also known as "Philips Semiconductors") Superfund site, which is not required by federal Superfund law to be included in the Five-Year Review because it is not listed on the federal National Priorities List (NPL), or "Superfund list." Together with the AMD and TRW sites, the Signetics site was originally proposed for listing on the NPL in 1984, but was removed from proposed listing because it was being regulated under a different federal program at the time.

EPA recently entered into an enforcement agreement with Philips Semiconductors, Inc. for the Signetics site, which requires the company to evaluate options for accelerating the groundwater cleanup at the site and assess indoor air quality in commercial buildings that may be at risk from solvent vapors rising from the contaminated groundwater.

In the 1980s, groundwater investigations began in the OOU (areas north of Duane Ave.) to find the extent of solvent contamination resulting from discharges at the nearby AMD, TRW and Signetics manufacturing facilities. Groundwater extraction and treatment across the entire Triple Site has been ongoing since 1982 to contain and treat the groundwater, contaminated with a variety of solvents including trichloroethene (TCE).

Cleanup activities at the source sites (AMD, TRW and Signetics) have included removal of leaking tanks and equipment and contaminated soils, and in-place cleanup efforts focusing on bioremediation, an approach that stimulates the naturally occurring underground soil microbes to break down the solvents into harmless salts. TCE indoor air sampling in residences, schools and businesses under EPA oversight is ongoing. To date, more than 200 households, classrooms and commercial buildings have been sampled. Mitigation systems are being installed wherever necessary to prevent unacceptable levels of TCE vapors from accumulating indoors.

EPA invites the community to learn more about this review process and provide input about progress of the clean-up. One way to get involved is to contact Alejandro Diaz, Community Involvement Coordinator, at (415) 972-3242 or diaz.alejandro@epa.gov. Questions may also be directed to Melanie Morash, Remedial Project Manager, at (415) 972-3050 or morash.melanie@epa.gov.

You can find more site information, including recent technical documents, at the following websites:

AMD Website: https://www.epa.gov/superfund/advancedmicrodevices
TRW Website: https://www.epa.gov/superfund/trwmicrowave
OOU Website: https://www.epa.gov/superfund/triplesite

CNS-3247408#

Appendix E: Interview Forms

Five-Year Review Interview Record			
Site :	AMD 901/902 Thompson Place Superfund Site, TRW Microwave Superfund Site and Offsite Operable Unit	**EPA ID No:**	

Interview Type: Phone
Location of Visit: none
Date: 22 March 2019
Time: 9:45AM

Interviewers

Name	Title	Organization
Melanie Morash	Regional Project Manager	EPA

Interviewees

Name	Organization	Title	Telephone	Email
Cristina Ballantyne	San Miguel Elementary	Principal		

Summary of Conversation

1) What is your overall impression of the project? (general sentiment)
I have found that the project is moving along and that the communication has been very strong between EPA and the school. I realized that there is a need for this project work (vapor intrusion). I found that that actual impact to the community has been minimal and that has been very helpful to the school.

2) What effects have site operations had on the surrounding community?
It has been positive and it is a non-issue. I do not see a need for heightened concern from parents but an awareness of the (vapor) situation. People that ask questions are able to be reassured by the EPA and the school because there has been a clear plan that has been executed. Having sampling planned helps the parents have confidence in the school and EPA and the school has been helped by the EPA. It has helped the community and people are feeling at ease.

3) Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
Yes, a lot of community members are in rentals and there are families that have questions if their building has been tested. I can't provide answers for them.
Melanie- I have been working with a number of landlords to get access to the properties. EPA has the authority to gain access to the properties for testing, but if the owners (landlords) do not grant access, then EPA must go through a legal process and that takes longer. EPA is continuing to work towards gaining access to conduct the vapor sampling, we hope to have it completed in the near future.

4) Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.
No we have not had any issues.

5) Do you feel well informed about the site's activities and progress?

I feel like I have a lot of information. Initially there was a lot of concern about the project from parents and the community, but I feel like the communication was really good and I had the proper information that we needed to provide the parents and the community.6) Do you have any comments, suggestions, or recommendations regarding the project?

6) Do you have any overall suggestions or recommendations for improvement?
I am really pleased with the process. I invited the superintendent and other school officials to this interview but everyone I asked said no to the invitation and they also commented that the result has been very positive. The only feedback the school has is for scheduling sampling. We do not who is responsible for the testing. It helps to be able to tell parents that EPA is continuing to test in winter and summer. We do not always know who is coming out (which company) and who is scheduling the testing. We understand that It all falls under the umbrella of EPA, but we do not always know exactly what and when it is happening. The school would like to know a year in advance if possible.

Additional Site-Specific Questions

7)Any other feedback?
No, it has been very good. Just more advance notice and just to say that the mitigation systems look good. She has been happy that were installed and are barely noticeable to the public.

M.M. -The contractors worked very hard to implement the mitigation measures. They took great care to install the systems and they will be happy to hear this.
Melanie project summary-
The legal agreement had an expiration date June 2016. EPA usually does not have an expiration date and no one noticed it. Eventually someone noticed the expiration date on the Order even though Phillips had been working diligently for sampling and installing mitigation systems. Once the expired EPA order was realized, EPA cannot formally oversee the work. Phillips has continued to work without EPA oversight. EPA is negotiating a new order including the source area where the Phillips facility use to be located (Signetics Site). We now have an order in place with Phillips with a new technology for bioremediation to eat up the solvents and degrade to harmless compounds. I have been working on the enforcement documents to resume EPA oversight of the Phillips work. We have been in the position of sampling, we would like to get to that point of concluding the indoor air sampling. EPA is working to have Phillips agree to preemptively to install mitigation systems on properties that are suspected. New order will hopefully be signed within the next year. Then we can reach out to you and then plan the next years sampling at Locus Consulting so you will know who is showing up for sampling.

C.B. How close are we from being done with testing?
M.M. You are not alone in asking that question. We do not have an answer yet but we are working on that.
C.B. It sounds like we are testing through next year? M.M. Yes, that is the plan.

C.B. - I want to say that the relationship between the school district and EPA has been very meaningful.
M.M. - Thank you. We are conducting investigations with other projects and we have worked very hard upfront to help relay information. The school has been so helpful and EPA is very grateful in your cooperation and efforts. Other projects have not had similar results and EPA believes that the positive support of the school has provided a good conduit for communicating to parents and the community.

Five-Year Review Interview Record			
Site :	AMD 901/902 Thompson Place Superfund Site, TRW Microwave Superfund Site and Offsite Operable Unit	**EPA ID No:**	

Interview Type: Sent questions via email
Location of Visit:
Date:
Time:

Interviewers

Name	Title	Organization

Interviewees

Name	Organization	Title	Telephone	Email
Jennifer Garnett	City of Sunnyvale	Communications Officer	408-730-7476	jgarnett@sunnyvale.ca.gov

Summary of Conversation

1) What is your overall impression of the project? (general sentiment)

The EPA project team was genuinely committed to informing our community, in particular the impacted residents, schools, etc. They involved the City and the school district with developing the outreach materials and were very receptive to our comments and input. They were also good partners with media inquiries.

2) What effects have site operations had on the surrounding community?

I am not aware of any effects. The school district may have greater insight into this due to their proximity to the location.

3) Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

Not at this time.

4) Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

Not aware of anything.

5) Do you feel well informed about the site's activities and progress?

Melanie Morash, the EPA project manager, and her team did a good job keeping us informed at various points in time through emails, in-person meetings and site visits. See #6 below for related suggestion.

6) Do you have any comments, suggestions, or recommendations regarding the project?

The longevity of the project makes maintaining continuity of information challenging. Many City staff members who were involved at the project's inception are no longer employed with us. For all similar projects, I recommend that EPA send out simple quarterly or semi-annual updates that help keep everyone up-to-date with progress. Even if the message is "no news" that is helpful.

Additional Site-Specific Questions

Five-Year Review Interview Record

Site :	AMD 901/902 Thompson Place Superfund Site, TRW Microwave Superfund Site and Offsite Operable Unit	**EPA ID No:**	

Interview Type:
Location of Visit:
Date: 2/19/2019
Time:

Interviewers

Name	Title	Organization

Interviewees

Name	Organization	Title	Telephone	Email
Heather O'Cleirigh	AMD	EHS Sr. Manager	512.602.1907	Heather.ocleirigh@amd.com

Summary of Conversation

1) What is your overall impression of the project? (general sentiment)
Good example of a project which does the work necessary to ensure the protection of human health and the environment, allows continued use of the land, and adapts clean up strategies for the best outcome.

2) What effects have site operations had on the surrounding community?
Not aware of any negative impacts.

3) Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.
Not aware of any.

4) Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.
A homeless person was found camping in the treatment system compound in 2017. No damage or theft was noted. The police department was notified and the possessions moved out of the compound, but no follow-up action was required.

5) Do you feel well informed about the site's activities and progress?
Yes.

6) Do you have any comments, suggestions, or recommendations regarding the project?
Continue partnership with the EPA and Water Board.

Additional Site-Specific Questions

Appendix F: Site Inspection Report and Photographs

Trip Report
Advanced Micro Devices, Inc. 901/902 & TRW Microwave Superfund Site, Sunnyvale, California

---

1. INTRODUCTION

a. Date of Visit: 14 March 2019

b. Location: Sunnyvale, California

c. Purpose: A site visit was conducted to visually inspect and document the conditions of the remedy, the site, and the surrounding area for inclusion into the Five-Year Review Report.

d. Participants:

Melanie Morash	USEPA Region 9 Remedial Project Manager (RPM)	(415) 972-3050
Diane Prend	USEPA Region 9 Office of Regional Counsel	(415) 972-3825
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Heather O'Cleirigh	Advanced Micro Devices, Inc.	
Shau Luen Barker	Phillips/Signetics	
Wes Hawthorn	Locus Technologies, President	(415) 799-9937
Africa Espina	Locus Technologies	
Dan Ducass	Locus Technologies	
Peter Bennett	Haley & Aldrich, Principal Hydrogeologist	
Michael Zlotoff	Haley & Aldrich, Technical Specialist	(408) 961-4810
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Todd Maiden	Reed-Smith (Counsel for PSI)	

2. SUMMARY

A site visit to the AMD 901/902 & TRW Microwave Superfund Site was conducted on 14 March 2019. All participants met off site for preliminary briefings and health and safety check in. The site is comprised of four Operable Units (OUs) including: Signetics Inc. (also known as "Phillips") Superfund site; AMD 901/902 Superfund site; TRW Microwave and Companies' Offsite OU Superfund site. The Site is comprised of light-industrial, commercial, and residential area. Remediation is currently being conducted consisting of Groundwater Extraction and Treatment Systems (GWETS), In-situ bioremediation (ISB), enhanced aerobic bioremediation (EAB) and soil vapor intrusion mitigation methods. Participants toured the sites and inspected the above-referenced systems.

3. DISCUSSION

On 11 March, Ben McKenna flew to San Jose, California to meet with multiple parties for five Year Review Site Visits at multiple sites. On 14 March Ben McKenna met the AMD 901/902 & TRW Microwave participants. The weather was sunny and warm (temperature approximately 65° F). The site is accessed from California Highway 101 South and Fair Oaks Avenue and is located northwest of downtown San Jose.

All participants met at an off-site location at 0830 and proceeded to the Offsite OU where Locus Technologies (Locus) operates a GWETS in the vicinity of San Miguel Elementary School. Locus gave an overview of the historical and current remedial operations and a brief background on the site history. All existing wells were secured, locked and in good condition. Locus discussed the ongoing vapor intrusion investigation work and provided examples of the different mitigations being employed for residential home and the school.

After viewing the visible components of the Offsite OU GWETS the participants traveled to the Signetics site to inspect the GWETS system at 813 Stewart Drive. Locus provided access to the GWETS system compound and gave a briefing of its system operations, maintenance schedules and overall performance. All components of the GWETS system including the extraction wells, conveyance piping and associated monitoring well appeared in good condition and functioning properly. After the briefing of the GWETS system Haley & Aldrich provided access to nearby extraction well S147B1 so that participants can view internal workings of the extraction well.

After inspecting the extraction well, the participants walked to the adjacent TRW site at 825 Stewart Drive to inspect the site. No active pump and treat remediation is occurring at the site and EAB is ongoing. AECOM provided an overview of the EAB remedial progress and participants viewed the former remedial compound and the EAB Injection wells on site. All injection wells and monitoring wells appeared in good condition and functioning properly.

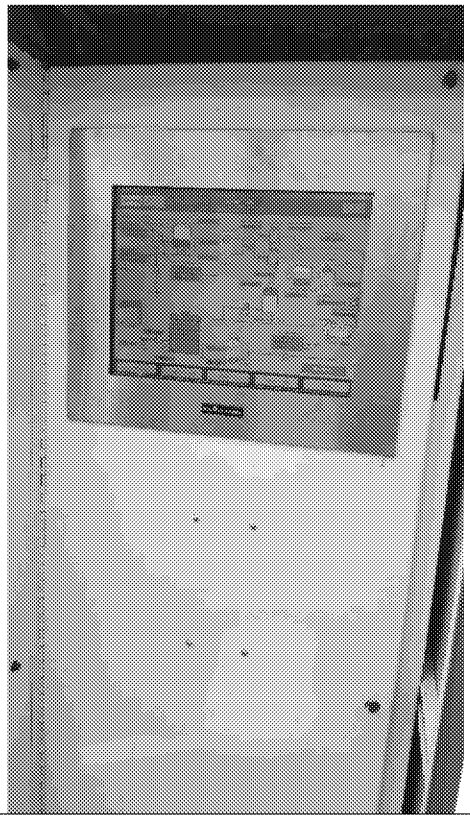
After a lunch break the participants resumed the site visit inspections at the former AMD 901/902 site at 875 East Arques Ave. Hayley & Aldrich gave an overview of the historical and current remedial operations and a brief background on the site history. Participants walked the site to observe the ISB injection wells and the former GWETS system compound. All injection wells and monitoring wells appeared in good condition and functioning properly.

After viewing the ISB injection wells at the AMD 901/902 the site inspection was concluded for the AMD 901/902 & TRW Microwave Superfund Site and all participants continued on to the adjacent AMD Building 915 Superfund Site for inspection. All participants left the AMD Bldg 915 Site by 1600.

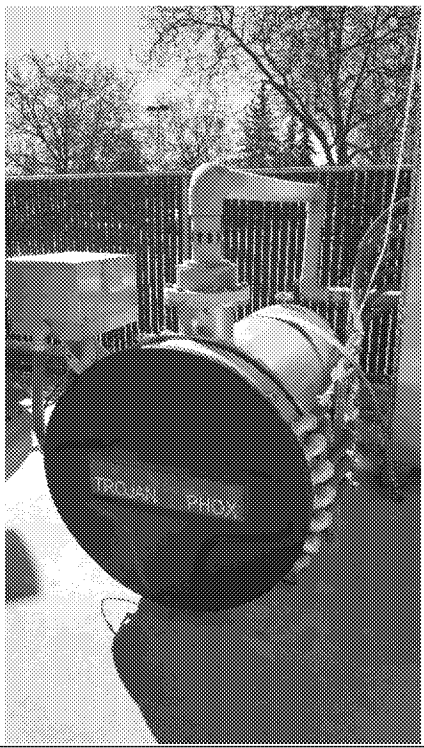
4. ACTIONS

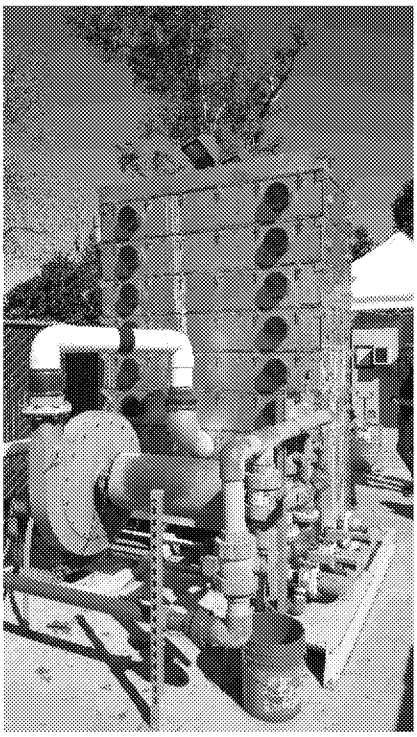
The USACE will incorporate information obtained from the site visit into the Five-Year Review report.

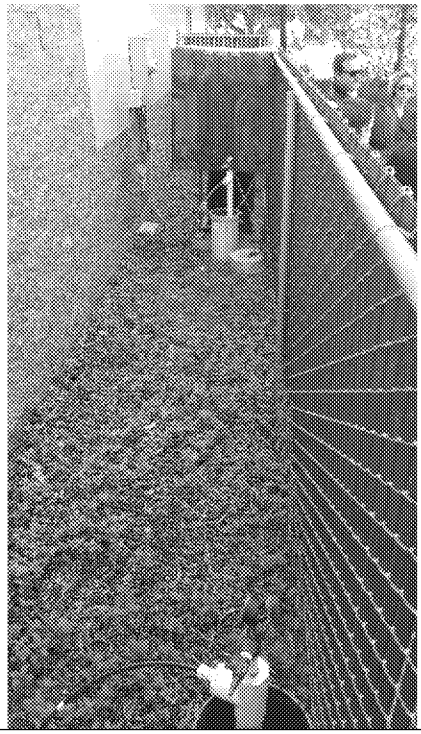
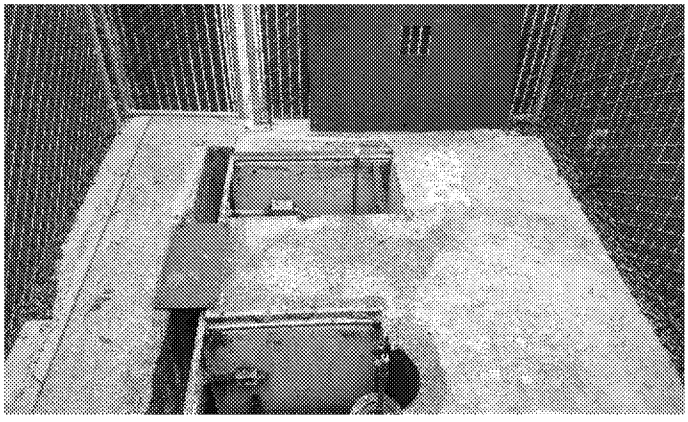
Phillips/Signetics GWETS Compound

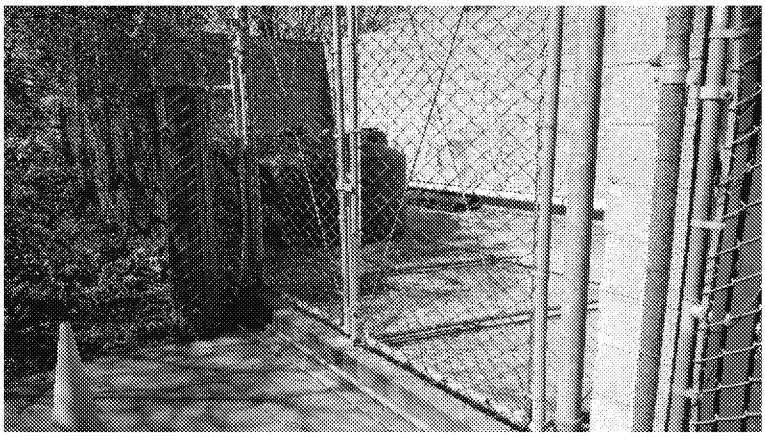


Phillips/Signetics GWETS Control Panel





Phillips/Signetics GWETS Ultra-Violet Treatment Unit	Phillips/Signetics GWETS Air-Stripper Unit
	
TRW Microwave Former Remediation Compound	TRW Microwave Monitoring Wells T-22B, T-23B & T-24B
	

AMD 901/902 A-Zone Injection Well ISB2AR & B-Zone Injection Well ISB3BR	AMD 901/902 Former Extraction Wells DW-1 & DW-2
	
AMD 901/902 Former Treatment System Compound	AMD 901/902 A-Zone Monitoring Well 28-MW

Appendix G: Site Chronology Table

AMD Chronology of Site Events

Event	Date
Advanced Micro Devices, Inc. (AMD) begins semiconductor assembly at 901 Thompson Place	1969
AMD begins semiconductor assembly at 902 Thompson Place	1972
Soil and groundwater contamination discovered	1982
AMD removes acid neutralization systems and associated contaminated soils from both 901 and 902 Thompson Place buildings	1983-1984
AMD begins groundwater extraction and treatment	1984
California Regional Water Quality Control Board, San Francisco Bay Region (Regional Board) issues Waste Discharge Requirements Order	Sept 1985
Regional Board adopts Site Cleanup Requirements (SCR) Order	Dec 1987
AMD 901-902 Thompson Place Superfund Site (AMD Site) listed on the National Priorities List (NPL)	June 1986
Baseline Public Health Evaluation (BPHE) completed	1990
Final Remedial Investigation/Feasibility Study (RI/FS) and Final Remedial Action Plan (RAP) approved for AMD Site and adjacent TRW Microwave Superfund Site (TRW Site) and Signetics Superfund Site (Signetics Site); Regional Board adopts Order #91-102 (Revised SCR)	June 1991
U.S. Environmental Protection Agency (EPA) issues Record of Decision (ROD)	Sept 1991
AMD ceases industrial operations at the AMD Site	1992
Regional Board and EPA complete first Five-Year Review (FYR)	Sept 1999
In-Situ Bioremediation (ISB) pilot project initiated in former volatile organic compound (VOC) source area at 901 Thompson Place	Sept 2004
Regional Board and EPA complete second FYR	Sept 2004
AMD conducts additional subsurface investigation	April 2005
Ex situ granular activated carbon (GAC) treatment system and carbohydrate injection system installed	Sept 2005
AMD begins full-scale ISB program	Dec 2005
AMD sells the AMD Site property	2005
On-site structures demolished by new owner	2006
A single commercial building constructed for use as a self-storage facility at the AMD Site and address changed to 875 East Arques Ave	2007
Ex situ treatment system reduced to one GAC vessel	Jan 2008
Regional Board issues No Further Action (NFA) letter for soil remediation	May 2008
The ISB program converted from active to passive with quarterly monitoring and intermittent active periods	May 2008
Regional Board and EPA complete third FYR	Sept 2009
Limited restart of ISB	Oct 2011 – Feb 2012
Carbohydrate addition and groundwater recirculation restarted	November 2012 - present
Focused Feasibility Study (FFS) completed	October 2013
Indoor air vapor intrusion investigation conducted	2013
Revised Focused Feasibility Study completed	Sept 2013

Event	Date
Haley and Aldrich (HAI), on behalf of AMD, submit vapor intrusion report to Regional Board, documenting findings of 2013 indoor air investigations which show no evidence of unacceptable vapor intrusion at the AMD Site buildings sampled	2014
AMD Site is transferred from the Regional Board to EPA Region 9, together with the other sites that make up the Triple Site	Aug 2014

TRW Chronology of Site Events

Event	Date
Aertech Industries begins microwave and semiconductor assembly and testing at the TRW Microwave Superfund Site (TRW Site)	1968
TRW acquires the property from Aertech Industries; no change in operations	1974
Soil and groundwater contamination discovered at the TRW Site	1983
California Regional Water Quality Control Board, San Francisco Bay Region (Regional Board) issues Cleanup and Abatement Order	June 1984
TRW removes underground solvent storage tanks, acid waste sumps and piping, and excavates soils	1984
TRW begins groundwater extraction and treatment system (GWETS) operation	1985
FEI Microwave acquires the property from TRW and continues operations	1987
Regional Board adopts Site Cleanup Requirements (SCR)	Jan 1988
Baseline Public Health Evaluation (BPHE) completed for the TRW Site	1990
TRW Site listed on National Priorities List (NPL)	Feb 1990
Final Remedial Investigation/Feasibility Study (RI/FS) and Final Remedial Action Plan (RAP) approved for the AMD, TRW, and Signetics Sites; Regional Board adopts Order #91-103 (Revised SCR)	June 1991
U.S. Environmental Protection Agency (EPA) issues the Record of Decision (ROD)	Sept 1991
Industrial operations cease at the TRW Site	1993
Regional Board and EPA complete first Five-Year Review (FYR)	Sep 1999
TRW suspends groundwater extraction in the former source area and initiates Enhanced Anaerobic Bioremediation (EAB) project in Zone B1 aquifer in former source area	Oct 2000
TRW suspends groundwater treatment throughout the TRW Site	Apr 2001
EAB expanded to Zone A	June 2001
Northrop Grumman Systems Corporation (Northrop) purchases TRW and the TRW Site	Dec 2002
CDM, on behalf of Northrop, evaluates vapor intrusion by sampling indoor air for volatile organic compounds (VOCs)	Oct 2003
Regional Board approves re-designation of TRW Site well 36D as a Zone A well rather than a Zone B1 well; Northrop sells TRW Site to Pacific Landmark, LLC	Aug 2004
Regional Board and EPA complete second FYR	Sept 2004
Indoor air sampling conducted without mechanical ventilation system in operation	Oct 2004
EAB pilot program expanded to include groundwater immediately downgradient of the former TRW Site source area (around wells T-8A, T-8B, and T-10B)	Aug 2005
EAB expanded (four new Zone A wells and one new Zone B1 well)	Sep 2005

Event	Date
Downgradient Zone A EAB treatment area expanded (seven new injection wells and one new monitoring well)	Aug 2007
Cheese whey injected into downgradient Zone A wells	Sept 2007 – June 2008
Regional Board and EPA complete third FYR	Sept 2009
GWETS dismantled and removed; trenches filled with concrete	Nov 2012
Regional Board issues requirements for additional vapor intrusion investigations	Dec 2012
Expanded source area investigation conducted	July 2013
Indoor air and sub-slab vapor sampling conducted, showing screening level exceedances and resulting in installation of a passive sub-slab venting system with the capability of being converted to active status if conditions warrant	Dec 2013 - present
TRW Site is transferred from the Regional Board to EPA Region 9, together with the other sites that make up the Triple Site	Aug 2014
Targeted excavation of the former source area using large diameter augers removing a total of approximately 590 tons of soil and 9,000 gallons of groundwater	Oct-Nov 2014
Emulsified vegetable oil injected under the building footings in the vicinity of the former source area	Dec 2014
Results of confirmation sub-slab and indoor air sampling verified the efficacy of the passive sub-slab ventilation system	June 2015
Updated Conceptual Site Model prepared for the TRW Site using environmental sequenced stratigraphy to better evaluate contaminant migration pathways	Apr 2016
Membrane interface probe (MIP) and hydraulic profiling tool (HPT) investigation performed to fill data gaps at the TRW Site	Nov 2016
Five monitoring wells installed based on the results of the MIP/HPT investigation	August 2017
Additional investigation performed at the northern property boundary, resulting in the installation of a dual-nested monitoring well	December 2018

Offsite OU Chronology of Site Events

Event	Date
Duane Avenue extraction system begins operation	1986
Carmel Avenue, Alvarado Avenue, and Ahwanee Drive extraction systems begin operation	1988
Baseline Public Health Evaluation (BPHE) completed for the combined sites of the Triple Site	1990
California Regional Water Quality Control Board, San Francisco Bay Region (Regional Board) issues Site Cleanup Requirements for the AMD, TRW, and Signetics Sites and Offsite Operable Unit (OU)	1991
U.S. Environmental Protection Agency (EPA) issues the Record of Decision (ROD)	Sept 1991
Additional wells installed in Carmel, Alvarado, and Ahwanee subsystems	1992
Philips Semiconductors, Inc. (Philips) initiates indoor air evaluations at a high school and elementary school on Duane Avenue which overly the highest concentrations of trichloroethene (TCE) in shallow-zone groundwater	2004
Groundwater extraction conveyance changed from the AMD 915 DeGuigne Drive Superfund Site to the Arques Avenue treatment system at the Signetics Site	Oct 2010
In response to the issuance of the EPA Region 9 vapor intrusion guidelines letter for South Bay Superfund sites, the Regional Board issues a requirement to Philips to prepare and submit for approval a vapor intrusion sampling workplan for the Offsite OU	Jan 2014
The Offsite OU is transferred from the Regional Board to EPA Region 9, together with the other sites that make up the Triple Site	Aug 2014
EPA issues an Administrative Order to Philips, requiring the preparation and implementation of a vapor intrusion sampling workplan for residences and schools in the Offsite OU	Mar 2014
Philips conducts vapor intrusion investigations and mitigations under EPA oversight, installing mitigation systems in more than 20 residential and school buildings to address findings of unacceptable vapor intrusion	2014 to present